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Twenty-two working papers dealing with reenlistment, delayed entry, enlistment, promotion, attrition, classification and assignment, the Army College Fund, supply forecasting, enlisted personnel, personnel allocation, the GI Bill, and manpower planning.

15. SUBJECT TERMS

Reenlistment, delayed entry, enlistment, promotion, attrition, classification and assignment, Army College Fund, supply forecasting, enlisted personnel, personnel allocation, GI Bill, manpower planning, DEP, ACF, AMCOS, EPICC, Project B, EPAS, Survey of Employers

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Working Paper MPPRG 86-12

THE EFFECT OF SELECTIVE REENLISTMENT
BONUSES ON REENLISTMENT AND EXTENSION IN THE U.S. ARMY*

by

Hyder Lakhani

Curtis Gilroy

Cavan Capps

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Reviewed by: David K Horne   Approved by: Curtis Gilroy

U.S. Army Research Institute
for the Behavioral and Social Sciences
5001 Eisenhower Avenue, Alexandria VA 22333

The Effect of Selective Reenlistment Bonuses on

Reenlistment and Extension in the U.S. Army

I. Introduction

The Army incurs a substantial resource investment in recruiting and training soldiers during their first enlistment terms of two, three, or four years. Returns to this investment are realized by the Army in the form of increased productivity through improved performance after training. The returns on this investment are expected to be larger, the longer the soldier's term, and even more substantial for certain soldiers with successive reenlistment or extension tours. To make reenlistment a particularly attractive option for select soldiers, a financial inducement in the form of a bonus is offered. Called the Selective Reenlistment Bonus (SRB), it is offered to specially qualified individuals who choose to reenlist in particular military occupational specialties (MOS) deemed either critical to the Army's mission or short in supply. Since military pay is virtually constant across occupations, the SRB is used as a compensating wage differential to increase reenlistments in the hard-to-fill MOS. As such, it has proven useful as a policy tool to insure an adequate balance between manpower supply and demand.

The purpose of this paper is to analyze the impact of the Selective Reenlistment Bonus on the supply of both reenlistments and extensions in the Army. Since the impact of this incentive on supply is likely to vary by occupation, we estimate separate effects for specific groups of MOS. As both reenlistments and extensions would tend to pull in opposite directions in response to an SRB, we estimate the net effect of both.

Section II provides a discussion of random utility maximization theory upon which our model is based. Section III presents the empirical estimation and a discussion of the results. Section IV provides concluding remarks and policy implications. The estimation of potential civilian earnings of soldiers is found in Appendix A and the derivation of

elasticities for a trichotomous logit model is included in Appendix B.

II. Theoretical Framework

Toward the end of his first term, a soldier is faced with a decision on three discrete choices: (1) separation from the Army at the end of the term, (2) a committment to an extension for a period of less than three years, or (3) a committment of reenlistment for a period of three to six years. An appropriate theoretical model to explain such a decision is that of random utility maximization initially developed by Thurstone (1927). A soldier is assumed to compare total utility (or satisfaction) obtained from pecuniary and non-pecuniary returns associated with any one of the three choices and selects the one which provides him maximum utility. The decision-making process of a soldier can be represented by

(1) $\text{Max } U_k = (X_k, Y_k, Z_k) + \varepsilon_k,$ for $k = 1, 2, 3.$

where

U_k = total utility derived from alternative k,

k = 1 for separation,

k = 2 for extension,

k = 3 for reenlistment,

X_k = pecuniary returns from alternative k,

Y_k = non-pecuniary returns from alternative k,

Z_k = personal (demographic) characteristics of soldiers.

ε_k = stochastic component of U_k denoting such non-observable individual traits as preference for military or civilian service, patriotism, etc.; with $E(\varepsilon_k) = 0$; $\text{cov}(\varepsilon_j, \varepsilon_k) = 0$, for $j \neq k$, and $\text{cov}(\varepsilon_k, X) = 0$. Assuming that an estimating

equation for U_k is linear in the attributes (reenlistment bonus and military pay) of the choice, personal characteristics of the soldiers, and the stochastic component ε_k, we have

(2) $U_k = X_k \ \beta_k + \varepsilon_k$

where X_k is a vector of explanatory variables (with corresponding fixed coefficient vector β_k) and ε_k is the random error term. An individual soldier will select an alternative k among the three available options if and only if

(3) $U_{kt} > U_{jt}$ for all $j \neq k$.

Since we are not able to observe the utility levels associated with the three alternatives, but instead observe only the three choices themselves, we represent them by the random variable w_t, where $w_t = 1$ if separation is chosen, $w_t = 2$ if extension is chosen, and $w_t = 3$ if reenlistment is chosen. Substituting (3) into (2), alternative j will be chosen ($w = k$) if and only if:

(4) $\varepsilon_{jt} - \varepsilon_{kt} > X_{kt} \ \beta_k - X_{jt} \ \beta_j \qquad j \neq k.$

This equation states that a randomly selected soldier t will select alternative j if the difference of the utility from unobservable taste variables of the jth and kth choices exceed the difference of the utility from the observable pecuniary variables. Since we cannot observe $\varepsilon_t = [\varepsilon_{1t}, \ \varepsilon_{2t}, \ \varepsilon_{3t}]$, we cannot calculate the difference between ε_j and ε_k and hence cannot determine if the inequality (4) holds. Assuming that the error terms have an extreme value distribution in the population, we obtain the Weibull distribution. McFadden (1974) shows that on the basis of this distribution, the logistic

probability that an alternative j will be chosen by the t'th soldier is given by:

$$(5) \quad P_j = \frac{e^{\beta_j X_t}}{\sum_{k=1}^{3} e^{\beta_k X_t}} \qquad j \neq k$$

where P_j = probability of choice j subject to the condition that a soldier t makes a choice k; X_t = explanatory variables for t'th soldiers; k = 0 for separation; 1 for extension; 2 for reenlistment; β = parameters

In order to estimate the parameters of equation (5), it is necessary to normalize them. This was done with respect to separation so that the coefficients of this base group are treated as zeros and those of the extension and reenlistment equations are estimated relative to separations.

The derivation of an elasticity with respect to an explanatory variable is shown in Appendix B. This formula is illustrated as follows with respect to the reenlistment choice:

$$(6) \quad E_{r,\, x_i} = \beta_{r,\, x_i} (1 - p_r)\, \bar{x}_r - \beta_{e,\, x_i} * p_e * \bar{x}_e$$

where

$e_{r,\, x_i}$ = elasticity of reenlistment probability with respect to explanatory variable x_i; $\beta_{r,\, x_i}$ = coefficient of explanatory variable x_i in the reenlistment equation; p_r = reenlistment probability; $\bar{x}_r$ = mean value of explanatory variable x_i in the reenlistment equation; $\beta_{e,\, x_i}$ = coefficient of explanatory variable x_i in the extension equation; p_e = probability of extension; $\bar{x}_e$ = mean value of explanatory variable x_i in the extension equation.

The most important variable for policy purposes is the selective reenlistment bonus (SRB). In FY1981, the maximum amount of SRB was $16,000 and the average amount

varied between $3,000 and $5,000. These payments are made to eligible soldiers who reenlist for a period of three to six years. The actual bonus payment varies across MOS according to the degree to which the MOS skill is currently deemed critical or high in demand. The bonus also varies in amount directly with the size of the soldier's monthly basic pay, and increases with the years of additional obligated service upon reenlistment. We calculated these amounts not only for soldiers who decided to reenlist but also for those who decided to extend or separate. The reason for assigning SRBs to both extendees and the separatees was that they were eligible to reenlist and, hence, had the opportunity to receive the bonus. The estimation of SRBs for these two groups of soldiers was based on the assumption that they would have reenlisted for an average term of service in their occupation. It was hypothesized that an increase in SRB would increase reenistments but decrease extensions.

The ratio of military pay to civilian earnings (RMC/W) was also included in the estimating equation. Military pay is comprised of a basic pay component to which were added basic allowances for quarters and subsistence, and the so-called federal tax "advantage." The allowances were adjusted with respect to pay grade, years of service and marital status. Potential civilian wages of soldiers were estimated from a civilian earnings equation discussed in Appendix A. It was hypothesized that an increase in the ratio of military to civilian pay would tend to increase both extensions and reenistment probabilities.

Unemployment (U) was also thought to affect reenlistment, and was measured by the unemployment rate of the state of residence of the soldier at the time of his enlistment. Theory would lead us to believe that the relationship between this variable and extension and reenlistment would be positive -- high civilian unemployment would result in higher reenlistment and extension probabilities.

Individual soldier characteristics included in the model consisted of race (RACE), score on the Armed Forces Qualification Test (AFQT), and the number of family

dependents (DEP). The AFQT variable was developed as a binary variable equal to 1 for those who scored in the upper fifty percent of the test (CAT I-IIIA high quality soldiers) and equal to zero otherwise. The expected sign of this variable is negative in the reenlistment equation; that is, higher quality soldiers tend to quit either for better civilian opportunities or to go to college.

The race variable was also binary and was equal to 1 for black, 0 otherwise. It was hypothesized that black soldiers have a higher probability to both reenlist and extend in the Army, due perhaps to the perception of greater opportunity for advancement in the military than in the civilian sector. The variable on the number of family dependents was also hypothesized to bear a positive relationship to reenlistment and extension probabilities; married soldiers with dependents were assumed to be more risk-averse, tending to remain in the Army rather than quit and face the uncertainties in the civilian labor market.

Data were obtained primarily from the Enlisted Master File (EMF) for fiscal years (FY) 1980 and 1981. A special match of these files determined the number of enlistees by their MOS who were eligible for reenlistment in FY 1981. These reenlistees decided to extend for a period of up to 3 years or to reenlist for 3 to 6 years and had made the decision during the "open window" period between 30 and 36 months of service.

In FY 1981, there were more than 300 MOS, of which 131 were eligible to receive the first-term SRB. In order to reduce the estimable equations to a more manageable number, conserve the degrees of freedom (some MOS are quite small), and provide more variation in the SRB variable itself, the MOS were grouped into 15 Career Management Fields (CMFs) as occupationally homogeneous as possible. The data were also sorted to include only those MOS for which an SRB was paid.

III. Data Analysis and Empirical Results

Tables 1 and 2 present mean values of the reenlistment and extension variables,

respectively, by CMFs. The number of eligible soldiers is the total number of soldiers who had the required length of service, were tested for their primary MOS skill, and had a score of 90 or above in any three or more aptitude test areas. Twelve out of fifteen multinomial logit reenlistment equations converged and had statistically significant log likelihood ratios. The empirical equation for the total of all CMFs in the reenlistment and extension equations are impressive (not shown). The SRB variable is positive and significant in the reenlistment equation and negative and significant in the extension equation, as expected. The pay variable is positive and significant in both and is also in accord with *a priori* expectations. AFQT is negative and statistically significant in the reenlistment equation indicating lower probability of reenlistment among higher quality soldiers. Both RACE and DEP are also statistically significant and positive in both the reenlistment and extension equations. The unemployment variable is contrary to expectations, although this finding is not surprising given the mixed results in the extant literature.

The empirical estimates at the disaggregated CMF level (not shown) demonstrated mixed results, although the performance of the SRB variable was impressive in both sign and statistical significance for the reenlistment and extension equations. The RMC/W variable, however, changed signs frequently and was generally insignificant. U had no explanatory power in the estimating equations, and two demographic variables -- CAT and DEPS -- did not contribute significantly to either the reenlistment or extension decision. The most successful of the demographic variables is RACE. Being black significantly increased the probability of extension in five of the 12 equations.

In terms of the SRB variable, the relationship to the reenlistment probability was positive, as expected, and significant in ten equations. The unexpected negative sign was observed for Field Artillery and an insignificant SRB coefficient was found for General Repairers. Elasticities, based on equation (6), are reported in Table 3. The values of SRB elasticities are all less than 1.0 (inelastic) and incorporate a rather wide range --

from 0.12 for Infantry to 0.98 for Air Defense Systems Maintenance. The elasticity value for an aggregation of all CMFs is around 0.5.

The values of reenlistment elasticities in Table 3 vary somewhat by occupation. Assuming an elasticity midpoint of 0.5, it is observed that occupations that tend to be more risky and dangerous (Infantry and Combat Engineers) or are highly skilled and, hence, in relatively high civilian demand (e.g. Health Care) generally tend to have elasticities of less than or equal to 0.5. On the other hand, occupations that are relatively less skilled, not easily transferrable to the civilian sector, and are lower in demand in the civilian sector tend to have elasticities in excess of 0.5, e.g., General Operators (0.52), General Machinists and Mechanics (0.52), Special Repairers (0.54), Air Defense Systems Maintenance (0.98) and Intelligence (not easily transferrable -- 0.72). Two exceptions to this are the Air Defense Artillery which is a risky and dangerous occupation and Traffic Controllers which has a high civilian demand.

It must be noted that the SRB elasiticities in Table 3 show the net increase in reenlistment probabilities; that is, these values are adjusted for the decrease in extensions given by the second term of equation (6). It is necessary to adjust for this decrease in a trichotomous framework of multinomial logit in which the explanatory variables in the reenlistment and extension equations for a given CMF are identical. Similar adjustments were also made in the extension elasticities shown in Table 3.

The calculation of elasticities in a multinomial system has progressed considerably in the last few years. This is one of the advances of this paper over the previous work of Ward and Tan (1985), Goldberg and Warner (1982), and Lakhani and Gilroy (1985). For example, Ward and Tan (1985) refer to the coefficient of an explanatory variable as elasticity (p. 30). Goldberg and Warner (1982) rightly derived the slopes of the conditional means of reenlistment and extension probabilities for the Navy and multiplied them by the average values of the variables, but excluded the second part of the elasticity formula. Lakhani and Gilroy (1985) also used the slopes of the conditional

means and, hence, erroneously obtained higher elasticities since they too excluded the second part of the formula. The SRB elasticities in Table 3 are considerably lower than those estimated earlier by Lakhani and Gilroy (1985).

Table 3 also reports the elasticities for the relative pay variable. As expected, these are positive and significant for five CMFs (including extensions and reenistments); but, in general, these results are disappointing.

Table 3 also displays the extension elasticities. As expected, the SRB effects are negative in all of the equations indicating that an increase in SRB would reduce extensions. These elasticities are generally higher than those for reenlistment and range from -0.63 to -1.85. They are also adjusted for the interaction effect and are smaller than those estimated in Lakhani and Gilroy (1985).

IV. Conclusions and Policy Implications

This research has attempted to apply Thurstone's theory of random utility maximization to first-term soldiers at their decision point to reenlist, extend, or separate from the Army. The model performed very well at the aggregate level, but the results of the equations were generally disappointing at the disaggregated occupational level. The effect of the selective reenlistment bonus (SRB) variable was still impressive, however, -- positive and statistically significant in the reenlistment equations and negative and significant in the extension equations. An increase in SRBs tends to increase the probability of reelistment and decrease separations and extensions. The elasticities (or responsiveness) of reenlistment to SRBs varied across occupations -- from 0.12 to 0.98. The SRB elasticities tend to be relatively smaller in occupations that are risky and dangerous or in high civilian demand, and higher in occupations that are not easily transferrable to civilian sector.

The estimating equations also included several other explanatory variables -- the ratio of military to civilian pay, unemployment, race, the number of dependents, and

soldier quality. Although the coefficients for these variables were significant at the aggregate level, they were relatively unimpressive at the disaggregated occupational levels. This latter finding points out a potentially serious problem of equation specification. A solution, of course, is to use perhaps a more comprehensive and differently specified set of independent variables, and an expanded and more recent data set. Both of these will be done in ensuing research.

TABLE 1

DESCRIPTIVE STATISTICS FOR REENLISTMENT

(Mean Values of Variables)

CMF	NUMBER ELIGIBLE	SRB $	RMC/W $	UNEMPLOY-MENT	% CAT I-IIIA	% BLACK	% WITH DEPENDENTS
11 Infantry	4,160	4,403	1.10	6.69	34	47	58
12 Combat Engineers	1 066	4 409	1.10	7.28	36	27	49
13 Field Artillery	2,028	4 391	1.09	6.93	27	58	66
16 Air Defense Artillery	549	4 907	1.10	6.82	26	54	44
23 Air Defense Systems Maintenance	192	4 429	1.06	7.25	33	58	58
27 Special Repairers	159	4,529	1.09	7.35	50	16	83
29 General Repairers	240	4 237	1.11	6.79	65	30	41
31 General Operators	1,070	4,374	1.07	6.57	20	60	39
63 Mechanics/ Machinists	2,358	4 440	1.11	6.78	20	36	50
64 Transportation	111	5.022	1.10	6.92	71	9	52
91 Health Care	1 559	4 405	1.08	7 27	56	36	54
96 Intelligence	175	3.511	1.12	7.85	70	12	43
Total	16,671	4.396	1.09	6.64	35	42	56

TABLE 2

DESCRIPTIVE STATISTICS FOR EXTENSIONS

(Mean Values of Variables)

CMF	NUMBER ELIGIBLE	SRB $	RMC/W $	UNEMPLOY-MENT	% CAT I-IIIA	% BLACK	% WITH DEPENDENTS
11 Infantry	4,160	2,050	1.09	6.61	35	48	60
12 Combat Engineers	1 066	2 047	1.11	7.23	36	27	47
13 Field Artillery	2,028	2,018	1.09	6.68	25	59	60
16 Air Defense Artillery	549	1.989	1.08	7.17	20	65	49
23 Air Defense Systems Maintenance	92	1 633	1.10	7.51	62	25	62
27 Special Repairers	159	2,240	1.12	7.22	77	22	32
29 General Repairers	240	1 907	1.09	7.05	71	19	61
31 General Operators	1,070	2,084	1.07	6.86	25	59	38
63 Mechanics/ Machinists	2 358	1 978	1.11	6.99	29	34	55
64 Transportation	111	2,134	1.11	7.74	84	19	57
91 Health Care	1 559	2 113	1.08	7.27	61	37	55
96 Intelligence	175	2,164	1.10	7.33	83	16	70
Total	16 671	2 050	1.09	6.66	38	41	55

TABLE 3

REENLISTMENT AND EXTENSION PROBABILITIES AND ELASTICITIES

CFM	AVERAGE REENLIST-MENT PROBABILITY	REENLISTMENT ELASTICITY		AVERAGE EXTENSION PROBABILITY	EXTENSION ELASTICITY	
		SRB	RMC/W		SRB	RMC/W
11 Infantry	.23	.12	NS	.18	-.91	1.64
12 Combat Engineers	.19	.51	NS	.16	-.78	2.24
13 Field Artillery	.25	-.10	1.18	.18	-1.85	-.13
16 Air Defense Artillery	.20	.85	4.67	.14	- .67	NS
23 Air Defense Systems Maintenance	.17	.98	NS	.17	-1.07	NS
27 Special Repairers	.19	.54	NS	.19	- .63	NS
29 General Rrpairers	.23	NS	NS	.13	- .83	NS
31 General Operators	.22	.52	NS	.17	- .95	3.37
63 Mechanics/ Machinists	.21	.52	NS	.17	- .73	NS
64 Transportation	.19	.65	NS	.23	- .90	NS
91 Health Care	.21	.51	NS	.15	- .80	NS
96 Intelligence	.23	.72	NS	.14	- .95	NS
Total	.22	.51	.55	.17	- .94	.82

NS = Coefficient was insignificant, hence elasticity was not calculated.

Appendix A

THE CIVILIAN WAGE MODEL

In order to present a realistic picture of labor market opportunities that enlisted personnel would face should they choose to leave the Army, their potential civilian earnings were estimated. These were derived from a civilian wage model based on the theory of investment in human capital — the idea that individuals do not necessarily consume for the sake of present rewards, but invest for the sake of future monetary and non-monetary returns. Individuals will invest today in education and training in anticipation of greater returns later. Earnings of individuals, then, are likely to be depressed during the time they are "investing in human capital," yet more than offset by higher wages in the later years of their working lives. The parameters to measure the monetary returns on this investment consist of the time spent in acquiring on-the-job training, relevant experience, and education. Blaug (1976, p. 837) notes that human capital theory predicts that the earnings-experience profiles of different educational cohorts will be concave from below, prediction that has been widely confirmed. Becker

(1975) demonstrated that the age–earnings profiles tend to be steeper among more skilled and educated persons. Psychological theory has taught us about "learning curves", whose declining slopes are explained in part by the natural depreciation of human capital. Hence, both theories suggest that wages increase as experience and education rise, but the growth rate of wages decreases as human capital deteriorates. Such a concave curve is denoted by a quadratic function in which the natural logarithm of wages is a function of the square of the experience term as the literature suggests.[1] Other factors such as age, race, sex, and marital status are often included as other explanatory variables in the civilian model of wage determination in order to avoid omitted variables bias.

The estimating equation specified here takes the form

$$(1) \qquad W = e^{B_0 + B_1U + B_2E + B_3X + B_4X^2 + B_5R + B_6M + B_7D + u}$$

Taking the natural logarithm of both sides of (1) we obtain

$$(2) \qquad \ln W = B_0 + B_1U + B_2E + B_3X + B_4X^2 + B_5R + B_6M + B_7D + u$$

where

W = annual wages earned in 1981

U = local area youth (19–22) unemployment rate

E = education (years of formal schooling)

X = weeks of experience

X^2 = X squared

R = race (1 = white; 0 = all others)

M = current marital status (1 = m ried; 0 = all others)

D = number of dependents

u = random error term

with the expectation that

$$\frac{\delta W}{\delta U} < 0 \; ; \; \frac{\delta W}{\delta E} > 0 \; ; \; \frac{\delta W}{\delta X} > 0 \; ; \; \frac{\delta^2 W}{\delta X^2} < 0 \; ; \; \frac{\delta W}{\delta R} > 0 \; ; \; \frac{\delta W}{\delta M} > 0 \; ; \; \frac{\delta W}{\delta D} > 0$$

Data

The data used are from the 1981 National Longitudinal Surveys of Youth Labor Market Experience (NLS), a national probability sample of approximately 12,000 individuals aged 14-24. This sample is superior to alternative sources of data which require the assumption that experience is given by age minus schooling minus six (Michael and Tuma, 1984). For the purposes of this research, we selected from this sample only male respondents in the 19-22 year old range.

We have further limited the sample by excluding those with a four-year college degree, since the comparable enlisted cohort is not likely to have completed college. We have, however, retained those respondents who have completed a two-year college education, since most of the enlistees at the end of their first term were either high school graduates at the time of enlistment or have since received training/education comparable to a two-year college education. We excluded workers who were also full-time students. An additional limitation was placed on the sample to include only those individuals who worked 35 or more hours a week (the official designation for full-time work) and who earned at least $1,000 in 1981. These restrictions, together with adjustment for missing values, diminished the sample size to 1,837. The discussion on the NLS questions used is presented in the data appendix. The descriptive statistics for the relevant variables are shown in Appendix Table 1.

TABLE A-1

DESCRIPTIVE STATISTICS OF THE NLS YOUTH COHORT, AGE 19-22, 1981
(N = 1,837)

Variable	Mean	Minimum Value	Maximum Value	Standard Deviation
Annual Wage ($ 1981)	$11,617	$1,040	$25,000	$4,428
Unemployment Rate (percent)	8.1	4.5	18.0	3.0
Education (years)	11.3	2.0	14.0	1.7
Experience (weeks)	98.4	1.0	313.0	70.2
Race (white)	-	0	1.0	-
Marital Status (married)	-	0	1.0	-
Number of Dependents	2.0	0	4.0	.8

Results

The results of the linear and log-linear regression equations appear in Appendix Table 2. The implicit civilian wages of first term Army enlistees are predicted from the values of the coefficients of the linear specification.

All coefficients exhibit the expected signs, and all important variables are significantly different from zero. The coefficients of determination are typically low, but their t ratios are significant at the .01 level, and the Durbin-Watson statistics indicate absence of autocorrelation of the residuals. Marital status (M) is conspicuously absent from the estimating equation because of multicollinearity with the number of dependents (D). We retain the latter since it generally contains the effect of marital status. The X^2 variable has the expected negative sign but is not statistically significant because of very small variation in the work experience of the 19-22 age cohort. Wages increase as experience gained on the job rises, but at a decreasing rate because of the depreciation of human capital.

In order to estimate civilian wages for enlisted personnel on the verge of their reenlistment decision, the significant coefficients in the linear equation were multiplied by the values of the independent variables for each individual. These were summed together (U was, of course, subtracted) and combined with the value of the intercept term to obtain the potential civilian wage. These estimates were then used as the denominator of the military-civilian wage variable in the reenlistment and extension model described below.

TABLE A-2

REGRESSION RESULTS FOR CIVILIAN WAGES OF THE NLS YOUTH COHORT, 1981
(N = 1,837)

Independent Variable	Linear	Log-Linear
Intercept	3,081.65* (3.07)	13.19* (154.49)
Unemployment Rate (percent)	-113.56* (3.2)	-.01* (3.6)
Education (years)	442.58* (6.33)	.03* (5.55)
Experience (weeks)	19.61* (2.59)	.01* (3.19)
Experience-Squared	-.01 (.63)	-.00 (1.14)
Race (white = 1)	527.00* (2.14)	.05* (2.46)
Dependents (number)	794.53* (6.63)	.07 (6.91)
Adjusted R-Squared	.12	.13
F Ratio	34.02*	35.87*
Durbin-Watson Statistic	1.77	1.79

t - ratios in parentheses.

*Significant at the .01 level.

Appendix B

Derivation of Elasticity Formula

In general, for a given X_j, the elasticity of the dependent variable (Y) with respect to X_j is given as

$$(B.1) \qquad E_{Yj} = \partial Y/\partial X_j * \overline{X}_j/\overline{Y}.$$

However, in a logistic model specification, the formula for calculating the elasticity is slightly different. Within a multinomial logit specification, the probability of a given outcome (ie - the dependent variable) is expressed as

$$(B.2) \qquad P_k = \frac{\exp(\sum_{i=1}^{I} \beta_{ik} X_i)}{\sum_{k=1}^{K}(\exp(\sum_{i=1}^{I} \beta_{ik} X_i))},$$

where P_k = the probability of the kth outcome,
β_{ik} = the coefficient of the ith explanatory in the kth equation, and
X_i = the ith explanatory variables. For simplicity it is assumed that
$X_{ik} = X_i$, for all k.

For the present case, the outcome set has three elements, or k = 0,1,2. As a simplification let $V_k = \text{sum}(i=1,I)\beta_{ik}X_i$. Therefore, the outcome probabilities are expressed as

(B.3) $P_0 = \exp(V_0)/(\exp(V_0) + \exp(V_1) + \exp(V_2))$,

(B.4) $P_1 = \exp(V_1)/(\exp(V_0) + \exp(V_1) + \exp(V_2))$, and

(B.5) $P_2 = \exp(V_2)/(\exp(V_0) + \exp(V_1) + \exp(V_2))$.

This can be further simplified by normalizing the coefficients of the first outcome to equal 0. Or,

(B.3') $P_0 = 1/(1 + \exp(V_1) + \exp(V_2))$,

(B.4') $P_1 = \exp(V_1)/(1 + \exp(V_1) + \exp(V_2))$, and

(B.5') $P_2 = \exp(V_2)/(1 + \exp(V_1) + \exp(V_2))$.

The first step in the derivation is to find the partial derivative of a particular P_k (say P_1) with respect to an X_j. This is given as

(B.6) $\partial P_1/\partial X_j =$

$$\frac{\beta_{j1}[\exp(V_1)][1+\exp(V_1)+\exp(V_2)]-[\exp(V_1)]\{\beta_{j1}[\exp(V_1)]+\beta_{j2}[\exp(V_2)]\}}{[1 + \exp(V_1) + \exp(V_2)]^2}$$

$$= \frac{\beta_{j1}[\exp(V_1)+\exp(2V_1)+\exp(V_1+V_2)]-\beta_{j1}[\exp(2V_1)]-\beta_{j2}[\exp(V_1+V_2)]}{[1 + \exp(V_1) + \exp(V_2)]^2}$$

$$= \frac{\beta_{j1}[\exp(V_1)] + [\beta_{j1} - \beta_{j2}][\exp(V_1+V_2)]}{[1 + \exp(V_1) + \exp(V_2)]^2} .$$

Substituting from equations (C.3') - (C.5') into equation (C.6) yields

$$\text{(B.7)} \qquad \partial P_1/\partial X_j = \beta_{j1}P_0P_1 + [\beta_{j1} - \beta_{j2}]P_1P_2$$

$$= \beta_{j1}(P_0 + P_2)P_1 - \beta_{j2}P_1P_2 .$$

Now, define $P_0 = 1 - P_1 - P_2$. Substituting this expression into equation (C.7) and further simplifying, gives

$$\text{(B.8)} \qquad \partial P_1/\partial X_j = \beta_{j1}(1 - P_1 - P_2 + P_2)P_1 - \beta_{j2}P_1P_2$$

$$= \beta_{j1}(1 - P_1)P_1 - \beta_{j2}P_1P_2$$

The final step needed to find the elasticity formula is to multiply equation (C.8) by $\overline{X}_j/\overline{P}_1$ and set $P_1 = \overline{P}_1$ and $P_2 = \overline{P}_2$. This yields an

expression for the elasticity similar to that in equation (C.1). Or,

$$\text{(B.9)} \qquad E_{1j} = \partial P_1/\partial X_j * \overline{X}_j/\overline{P}_1 = [\beta_{j1}(1 - \overline{P}_1)\overline{P}_1 - \beta_{j2}\overline{P}_1\overline{P}_2]*[\overline{X}_j/\overline{P}_1]$$

$$= [\beta_{j1}(1 - \overline{P}_1) - \beta_{j2}\overline{P}_2]*\overline{X}_j \ .$$

It is not difficult to derive similar expressions for the other model outcomes.

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Working Paper 87-30

A MODEL OF THE IMPACT OF INCENTIVES

ON SECOND TOUR PERFORMANCE

(NOT REVIEWED FOR SINSITIVITY: INTERNAL ARI DISTRIBUTION ONLY)

ABRAHAM NELSON

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REVIEWED BY: Edward J. Schmitz

APPROVED BY: Curtis L. Gilroy

U.S. Army Research Institute for the Behavioral and Social Sciences
5001 Eisenhower Avenue, Alexandria VA 22333

P08802

A MODEL OF THE IMPACT OF INCENTIVES ON SECOND TOUR PERFORMANCE

I. INTRODUCTION

Since the early 1980's the quality of the personnel entering the U. S. Army has steadily improved. The enlistment of both the percentage of high school graduates and the number of individuals scoring above the fiftieth percentile, i. e. (test categories I-IIIA) on the Armed Forces Qualification Test (AFQT), has increased during this period. During the early portions of this period high unemployment rates among the teenage population which constitutes the primary source of recruits for the Army, made it easy to recruit high quality individuals. Since that period, however, general economic conditions have improved. This has made it more difficult to attract high quality recruits. Hence it has become necessary to offer both monetary and nonmonetary incentives to induce individuals to enlist. The cost of these monetary incentives to attract and retain high quality recruits has made it essential for the Army to justify its need for the quality goals sought. The objectives of these requirements are to insure that future leadership and desired performance requirements for MOS are met. The primary focus of this paper is on the impact of such incentives on second tour performance, and the impact of goals for second tour performance on recruiting objectives.

Individuals during their second tour fulfill, not only immediate Army manpower needs but are also the primary pool from which the future noncommissioned officers of the MOS are developed. The individuals who are in their second tours are the leaders and the on-the-job trainers of new recruits. They also form the pool of individuals from which the career force members are selected. The Army's manpower system is a bottom-up system. That is, individuals enter the system, with few exceptions, at the

bottom and are promoted from within. It is necessary to recruit quality individuals to meet second tour and career quality requirements. Although it may be possible to meet high quality requirement through MOS migration, high retraining costs make this an undesired approach. Hence the Army's quality requirement for MOS, which is its assessment of the number of noncommissioned officers needed for leadership, must be met primarily by first term recruits.

To meet its high quality requirements the Army has several policy tools. The principal ones, however, are the economic incentives it offers for joining and reenlisting in the Army. These incentives are the enlistment bonus, the Army College Fund (ACF), and the selective reenlistment bonus (SRB) programs. The enlistment bonus and the ACF increase the supply of high quality individuals available to the Army. The SRB serves to increase the number of high quality individuals retained in a MOS.

The objective of this research is to determine the impact of various levels of economic incentives on second tour performance. It is not the intent of this paper to determine optimal incentive levels. Rather incentive levels will be assumed and the consequences of those assumptions will be scrutinized. Predicted second tour performance will be examined. All of the above will be done taking into account pertinent cost elements.

II. THE MODEL

This section of the paper is organized in the following fashion. First a conceptual description of the model is presented. Secondly, variables used and the equations involved are defined. Next, the cost and performance measures are presented. Finally, a mathematical description of the model is given.

Conceptual Model

The model considered in this paper is a deterministic multiperiod linear programming model. The objective of this model is to minimize cost while meeting the manpower and second tour performance requirements for a MOS. The total manpower requirements and the required quality distributions are taken as given in this paper. For various incentive programs, which are composed of different levels of the enlistment bonus, ACF, and reenlistment bonus, an accession policy will be determined which satisfies the above. To summarize, the purpose of this model is to determine an accession policy which meets the manpower and performance requirements for the least cost.

The number of high quality individuals who enlist in the Army is influenced by economic conditions, the number of recruiters, the number of high quality individuals available, Army and civilian pay, and other factors. (Army pay includes enlistment bonuses and the Army College Fund.) Fernandez (1982) and Daula and Smith (1986) and Polich, Dertouzos, and Press (1986) have demonstrated that such incentives increase the supply of enlistments in the Army. Their supply equations include the factors influencing enlistment noted above. The supply equation is exgoneous for the analysis considered here. The model, however, is estimated for various enlistment bonus and AFC levels.

Recruiting costs are also taken into account in this model. These costs include the cost of recruiters, marginal cost of a high quality recruit, and enlistment bonus and ACF cost. The marginal cost of low quality is assumed to be zero. The sum of these cost elements determines the cost of obtaining another enlistee.

Every nonprior service individual who joins the Army is required to go through both basic and advance individual training (AIT). Basic training

normally lasts eight weeks. Everyone must go through the same basic course. After basic training enlistees enter AIT. The time spent in AIT varies from six weeks to over a year depending on the Military Occupational Specialty (MOS). The time spent in basic training and AIT is assumed to be nonproductive.

Individuals attrite, or leave the Army before completing their military service obligation, during both basic training and AIT. Attrition rates vary by race, gender, high school status, AFQT category, and the amount of time spent in the Delayed Entry Program (DEP). Most studies have found that the largest and most significant factor influencing attrition is high school status. The attrition equations used in this analysis are also assumed to be exogenous.

Substantial costs are incurred during training. The marginal cost of each trainee is taken into account in this analysis. The AIT costs differ for each MOS. The costs of training in the technical MOS can be very expensive. When an individual attrites from training, the Army incurs costs for that individual. Also, that individual does not contribute any productive time to the Army. Trainees receive pay and allowances which are also costs to the Army during training.

Upon the completion of training, an individual is assigned to a job. In most instances it is the job for which he or she was trained. Nevertheless, there is a period of approximately one year during which on-the-job training occurs. The Army, in addition to pay and allowances, incurs on-the-job training costs during this period.

Prior to an individual's expiration of term of service (ETS) he or she, if eligible, is given the option to reenlist. To induce high quality eligible individuals to reenlist in certain MOS the Army offers selective

reenlistment bonuses. This reenlistment decision is modeled by most researchers using logistic regression models. The independent variables employed in these models are gender, race, education status, other demographic factors, AFQT category, the ACF, military and civilian pay, and reenlistment bonuses. The reenlistment equation used in this analysis is assumed to be exogeneous to the model. The analysis is conducted for different reenlistment bonus levels, however.

If an individual reenlists, he or she enters their second tour of duty. During this career phase individual receives pay and allowances as he received during other career phases. An examination of performance during this career stage is conducted here.

Second Tour Performance Measures

Currently the Skill Qualification Tests (SQTs), which were designed to determine the Army's training needs, are the Army's best measure of job proficiency. The SQTs are designed to assess performance on critical tasks of MOS. These tests are criterion referenced tests. The contents of the tests are based on job requirements as specified by experts. The meanings of the resulting test scores are also specified by experts. Although the SQTs are not the ideal measures of job proficiency they are best the Army has at this point in time. The U. S. Army Research Institute is currently developing improved measures and predictor of second tour job proficiency under a project referred to as Project A.

Maier and Grafton [1981] established relationships between the aptitude area composites of the ASVAB and SQTs. They showed that the ASVAB had validity coefficients ranging from .52 to .75 in predicting performance on the SQT. If the SQTs are reliable measures of job proficiency then the ASVAB composites are good predictors of job proficiency.

In this report the concern is with predicting the probability of obtaining a score of at least a certain amount. Horne and Grafton [1986] estimated a logistic model which accommodates the goal of this effort. In their model the following factors are considered: (a) ASVAB aptitude area composites, (b) high school status, (c) time in the service, (d) whether the individual has a GED or not, (e) years of education completed, and (f) if the individual is working in his or her training MOS. The aptitude area composites were significant determinants of probability of obtaining a given score for a MOS. In the case of MOS 19E and 19D, which are the MOS to be examined in this report, this was the only significant variable.

<u>Mathematical Description:</u>

A mathematical description of the model is now presented. First the variables and parameters used in the model are defined. Next, the model is described.

In this model four career stages will be considered. The variable k represents the career stages. Enlistment, first tour, eligibility for second tour, and the second tour are represented by the indicies 1,2,3, and 4 respectively.

The index i is used to represent the categories of individuals considered in this analysis. It indicates the race, AFQT category, term of enlistment, and educational status of a group. (Gender is not a factor since the model is applied to a combat MOS.)

The variables are defined as follows:

Let CE_i = the marginal cost of an individual in the i^{th} group enlisting.

Let EB_i = the enlistment bonus for the i^{th} group.

Let ACF_i = the cost of educational benefit of the i^{th} group.

Let LL = A large number which indicates that the supply of low quality (for all practical purposes unlimited).

Let TR = the total requirement for the k^{th} career stage.

The decision variables for the model are now defined. Let the variable $X_i(k)$ represent the number of individuals of the i^{th} group during the k^{th} career stage.

Several parameters employed in this model are estimated externally. In this report these parameters are estimated from models developed by other researchers. Parameters for a enlistment supply model, attrition rates, and reenlistment rate model models are determined. Descriptions of these models are presented in the appendix. These parameters are represented by the following:

Let S_i = the supply of individuals in the i^{th} group.

Let $a_i(k)$ = the attrition rate for the i^{th} group during the k^{th} career stage for the MOS under consideration.

Let $r_i(k)$ = the reenlistment rate for individuals in the i^{th} group during the k^{th} career stage for the MOS under consideration.

As noted earlier, the measures of performance considered in this paper are the SQTs. The probability of obtaining a score of 80 or more on the skill level two SQT was estimated using the model developed by Horne and Grafton [1986]. In their model the following factors were taken into account:

(a) ASVAB composites, (b) years of education completed, (c) whether a GED was received or not, (d) high school completion status, (e) the amount of time spent in the service, (f) gender, and (g) whether the individual is serving in his or her training MOS.

Their model formulation is a logistic regression model. It has the following format:

$$PSQT_i = 1/[1+\exp-(a_i^0 + a_i^1 * composite + a_i^2 * ED\text{-}Yrs + a_i^3 * GED + a_i^4 * HSDG + a_i^5 * SER\text{-}TIME + a_i^6 * GENDER + a_i^7 * TRMOS)]$$

This equation is used in estimating the performance term in the constraint set of the model.

The cost terms of the objective function are now presented. There are several component to the total cost function. They are enumerated below.

1. Cost of enlistment

$$C1 = SUM_i\ X_i(1)*[CE_i + EB_i + ACF_i]$$

2. Cost during second tour

$$C2 = SUM_i [SUM_i [SRB_i * X_i(4)]$$

The total cost through the second tour C = C1 + C2.

The model is depicted as follows:

MINIMIZE C

Subject to

$SUM_{i>}\ X_i(1) = S_i$ (Supply),

$SUM_{i<}\ X_i(1) <= LL$,

$X_i(k) = X_i(k-1) - a_i(k-1)*X_i(k-1)$ for k=2,3

(Transition),

$X_i(k) = X_i(k-1) - (1-r_i(k-1))*X_i(k-1)$ for k>3

$SUM_{i>}\ X_i(k) => R(k)$ (Requirements),

$SUM_i X_i(k) = TR(k)$, and

$X_i(k) => 0$.

The model above is a linear programming (LP) problem. A solution to it can be obtained using a LP code.

III. IMPLEMENTATION

Before the model developed in this paper can be estimated crucial data elements and econometric models must be identified. Cost data, AFQT distribution data, and total manpower requirements are needed. The primary source for the cost data will be the Army Manpower Cost system. The bonus and ACF cost are determined from other sources.

The source for the manpower requirements data is the FY81 cohort data files. The MOS which will be examined in this analysis is 19A. The manpower and AFQT distributional requirements for this MOS are assumed to be the levels actually obtained in the MOS. It is assumed that the portion of the level achieved in this MOS by this cohort is the requirement for this cohort in this MOS.

A review of the literature will be conducted to identify possible supply, attrition, and reenlistment models to be used in this analysis.

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A MICRODATA ANALYSIS OF LOSSES FROM THE DELAYED ENTRY PROGRAM

ABRAHAM NELSON

February 1988

Reviewed by:

Approved by:

Curtis L. Gilroy
Chief, Manpower and Personnel
Policy Research Group

Cleared by:

for NEWELL K. EATON, Director

Manpower and Personnel Research Laboratory

U. S. Army Research Institute for the Behavioral and Social Sciences
5001 Eisenhower Avenue, Alexandria, VA 22333-5600

A MICRODATA ANALYSIS OF LOSSES FROM THE DELAYED ENTRY PROGRAM

I. INTRODUCTION

The Delayed Entry Program (DEP), an important management tool for the U. S. Army Recruiting Command (USAREC), permits individuals to report for active duty up to twelve months after signing an enlistment contract. The vast majority of recruits enter the Army through this program.

One of the negative aspects of DEP is DEP loss, individuals abrogating their enlistment contracts. Recently, this has become an acute problem.

This report examines the DEP loss problem. The behavior of individuals in the Army's prime recruiting market, high school graduate and high school senior males scoring in or above the fiftieth percentile on the Armed Forces Qualification Test (AFQT), referred to as GSMA is examined. This group is of particular interest to the Army since it is supply constrained.

Two previous studies are relevant to the present research. Phillips and Schmitz (1985) estimated a microdata-level models of DEP loss using data from the first six months of the FY82 and the FY83 USAREC Minimaster contract files. They found the following factors statistically significant at the .10 level in at least one of their models: race, age, a four year enlistment term, enlistment bonus, Army College Fund (ACF), AFQT, sex, education level, and days in DEP. The following factors are negatively correlated with DEP loss: non-white, age, ACF, and AFQT. They also found that contracted days in the DEP and being a

female recruit are positively correlated with DEP loss.

Quester et al. (1986) developed a microdata-level model for the Navy. Their model included all of the factors noted above except term of enlistment and ACF which is not available in the Navy. Other factors considered in this model were the program enlisted for, month of enlistment, average number of recruits in the DEP per recruiter, and recruiting area. They found the following: (a) female recruits and younger male recruits are more likely to be DEP losses, (b) Navy enlistment incentive programs do not make a difference, (c) there are differences between regions of the country, (d) DEP loss appears higher when the DEP pool is largest, (e) the average monthly DEP size per recruiter is positively correlated to the probability of being a DEP loss.

This research builds upon the studies noted above. Using individual level data on GSMAs, an empirical analysis is conducted to identify those individual characteristics, enlistment policies, and environmental conditions which explain DEP loss. If individuals who have a high probability of becoming DEP losses can be identified then the recruiter's awareness of this potential problem may reduce the realization of DEP losses.

Section II develops a theory for explaining DEP loss. Results are reported in Section III, while summary remarks are presented in Section IV.

II. MODEL DEVELOPMENT

In this research effort it is assumed that individuals attempt to maximize the value of their job choice. When someone signs an enlistment contract they have judged that the value of

the Army job is greater than all other alternatives. While in the DEP an individual may continue to evaluate his choice. The value of the job choice may change as additional information is obtained and information is reevaluated. Additional information may come in the form of job offers from the civilian sector or other military services, changes in the perception of Army life or the MOS assignment, or the acquisition knowledge of educational opportunities.

If after a reevaluation, the value of the Army job is less than other alternatives then the individual becomes a DEP loss. Those individuals failing to fulfill their DEP contract exhibit quit behavior. The Army is passive in the DEP loss decision. While the Army is obliged to comply with an enlistment contract if the individual complies with the stipulation of that contract, the individual may abrogate it with impunity. The Army does not force individuals to comply with their enlistment contract.

To explore hypotheses on the effect of various factors such as individual characteristics, Army enlistment policies, and environmental factors of the individual on DEP loss, a microdata-level model is developed. If individual characteristics and environmental conditions can be identified for which DEP loss is more likely, then intervention programs may be designed to reduce this likelihood. If Army policies can be identified which influence DEP loss then it may be possible to change these policies to reduce probability of DEP loss.

The individual characteristics examined are age, AFQT score,

educational status, and whether the individual has dependents or not. The enlistment policies examined are ACF participation, whether he contracted for an enlistment bonus, term of enlistment, and contracted DEP length. Brigade dummies are used as surrogates of the environmental factors of the community from which the recruit enlisted.

The factors above are presumed to influence the probability that a recruit becomes a DEP loss. The following specific hypotheses are proposed:

(a) Age is negatively related to DEP loss. Other researchers have found that job turnover is greatest among younger individuals.

(b) AFQT is positively related to DEP loss. Since AFQT is a measure of mental ability then individuals with high AFQT scores should have more job options and educational opportunities than those with lower scores. Thus the higher the AFQT score the more likely an individual is to be a DEP loss.

(c) Contracted DEP length is positively correlated with DEP loss. The longer an individual is in the DEP the more opportunities he has to reevaluate his job choice.

(d) The behavior in the DEP of high school graduates and high school seniors is different. Seniors have less job market experience than high school graduates.

(e) Participation in the ACF or the enlistment for bonus program increases the value of Army job to the individual. Hence participating in these programs should be negatively related to the probability of DEP loss.

(f) Those individuals with dependents are more risk averse than those without dependents. The more risk averse an individual the less likely he is to change jobs. This implies that individuals with no dependents are more likely to be DEP losses than those without dependents.

(g) As terms of enlistment increase holding other factors constant the probability of becoming a DEP loss increases.

(h) Labor market conditions are not the same in different regions of the country. Brigade dummies are included to capture the different local labor market conditions.

It is also hypothesized that the impacts of certain factors on the probability of becoming a DEP loss are not linear and that some factors interact. As a result squares of age and DEP length are factors in the model. If these factors are statistically significant this implies that the marginal DEP loss rates with respect to these factors are not constant. The interaction of educational status with DEP length and DEP length squared is also considered here. This is included to investigate whether the impact of DEP length on DEP loss is different for individuals of different educational levels.

A logistic regression (logit) model is specified here. Let T be the random variable with the logistic distribution, $F(t)=e^t/(1+e^t)$. Suppose that Y=1 indicates a DEP loss if and only if $t \leq \Sigma_i \beta_i X_i$. Then

$$P(Y=1) = P(T \leq \Sigma \beta_i X_i) = e^{\Sigma \beta_i X_i}/(1+e^{\Sigma \beta_i X_i})$$

which is equivalent to

$$P(Y=1) = P(T \leq \Sigma \beta_i X_i) = 1/(1+e^{-(\Sigma \beta_i X_i)}),$$

where P(i) is the probability that the i^{th} individual becomes a DEP loss; β_i are logistic regression coefficients; and X_i are the factors associated with the i^{th} individual. (A graph of the logistic distribution is provided in Appendix A.)

Care must be taken in the interpretation of the coefficients of a logistic regression model. The estimated coefficients do not indicate the increase in the probability of a DEP loss given a one unit increase in the factor associated with that coefficient. Rather the coefficients indicate the increase of log(P(i)/(1-P(i))), the log odds of a DEP loss, for an increase in a factor.

Models are estimated using FY86 and FY87 USAREC Minimaster contract files. After eliminating open records and those with invalid information for the factors being analyzed, there are 87,997 and 73,233 remaining in the FY86 and FY87 files, respectively.

III. RESULTS

The variables in the model are age, age squared, DEP length (in months), DEP length squared, AFQT, education (high school degree graduates - HSG, high school seniors -SEN), ACF participation (ACF-YES, ACF-NO), bonus participation (BONUS-YES, BONUS-NO), dependent status (Dependent-yes, Dependent-no), Term of enlistment (TERM_2, TERM_3, TERM_4), the interaction of DEP length and education, the interaction of DEP length squared and education, and dummies for each brigade (BDE_1, BDE_2, BDE_4, BDE_5, AND BDE_6). The omitted categories are no ACF, no Bonus, dependents, four-year term of enlistment, and brigade 1.

The means for the variables in the model for FY86 and FY87 are reported in Table 1. A comparison of means for the fiscal years finds that the differences are very small for the majority of the variables. For example, there was only a two percent increase in the DEP length between FY86 and FY87. Note however, that there were substantial changes in participation for the Army's enlistment incentive programs: ACF and the bonus program. Participation in the ACF decreased by 20 percent between FY86 and FY87. The decrease in enlistment bonus participation was even greater: a 43 percent decrease occurred. DEP loss rates are also reported for each fiscal year in Table 1. Note that a 20 percent increase in the DEP loss rate occurred.

The results from the estimation of the two logistic regression models for 1986 and 1987 are reported in Tables 2 and 3. The coefficients and their standard errors are reported for both tables. The * (**) in the final column indicates that the factor is statistically significant at the .01 (.05) level. Observe that the signs of the estimated coefficients are consistent across models except for the coefficients of ACF and bonus. Also, the magnitudes of the coefficients are approximately the same in both models except for the intercept term and dependent status.

The model results determined that some individual characteristics, environment factors, and enlistment incentives impact the probability of DEP loss. As an individual grows older or the contracted DEP length increases the likelihood of them becoming a DEP loss increases. These rates are increasing at

decreasing rates since the sign of their square terms are negative. The education level of an individual or whether he has dependents affects his probability of being a DEP loss. The probability of DEP loss decreases as AFQT increases. Note that the coefficients for age and AFQT do not have the expected sign.

Other variables such as term of enlistments and the brigade dummies are not statistically significant in all instances. The brigade dummy for the third brigade in the FY86 model is not significant. Also, the two-year term of enlistment in the FY87 model is not significant. However, the signs of the coefficients for these variables are consistent across models.

The results of the models are inconsistent for the ACF and enlistment bonus program. ACF participation is statistically significant in the FY86 model and bonus program participation is not. The reverse is true for the FY87 model. In addition, the signs are negative in the FY86 model and positive in the other model.

An F-test of the chi-square summary statistics for each model indicates that at least one of the factors affects the probability of being a DEP loss in each instance. A pseudo-R^2 is reported in both tables. As expected, they are small: R^2=.35 for the FY86 model and R^2=.31 for the FY87 model. The percent of correct predictions for the model data is also provided in each table. They are, respectively, 73 and 72 percent. These statistics indicate that the explanatory power of each model is statistically significant. The effect of several of the factors on the probability of DEP loss for high school graduates

and high school seniors is examined in more detail. These factors are time in the DEP, age, AFQT score, brigade differences, and dependent status. While these factors are varied the others are held at their mean values.

The DEP loss probabilities for high school seniors and high school graduates for various DEP length are reported in Figures 1 and 2 for FY86 and FY87, respectively. As DEP length increases the probability of being a DEP loss increases. In both instances the DEP loss probabilities for seniors exceed those of the high school graduates during the first three months. After this point, however, the graduate probabilities exceed those of the seniors. The differences between these two increases rapidly after the fourth month. The high school graduate probability is approximately double that seniors for a DEP length of eleven months in both models. This indicates that for the average individual in both FY86 and FY87 that for a DEP length of eleven months a high school graduate is twice as likely than a senior to be a DEP loss.

Figures 3 and 4 present DEP loss rates for the FY86 and the FY87 models for seniors and graduates where age is allowed to vary from 17 to 35 years for graduates and from 17 to 21 years for seniors while holding all other factors at their means. These figures indicate that older individuals are more likely to become DEP losses. The graduate DEP loss probabilities exceed the seniors' in all instances. Note, however that the differences are very small.

In figures 5 and 6 the DEP loss probabilities for both

models are presented for seniors and graduates for various AFQT levels while holding the other factors, as before, at their means. These figures indicate that the higher an individual's AFQT score the less likely he is to be a DEP loss. The graduate probabilities exceed the seniors' in all cases. The differences between the two are approximately the same for all AFQT levels. There is a decline of approximately 19 percent in the DEP loss probability if AFQT scores are increased from the 50^{th} to the 90^{th} percentile. The range of the DEP loss probabilities is very small for this situation.

The DEP loss probabilities for each brigade and model are presented in figures 7 and 8 for graduates and seniors, respectively. These probabilities are estimated for the average individual in each brigade for each year. (These averages are reported in Appendix B.) The FY87 DEP loss probabilities exceed those for FY86 in all brigades for both graduates and seniors. The differences, however, are much larger for the graduates. Also, the results in the 1st brigade exceed those of all other brigades when comparisons are made of each model within educational levels.

Both models suggest that having no dependents is positively correlated with the probability of being a DEP loss. In fact the coefficients for this variable are the largest in absolute value in both models. This indicates that they have the most influence on the probability of DEP loss. But also note that the differences in the coefficients between models are largest for this variable. This indicates an instability in the estimated

impact of this factors.

IV. SUMMARY

The results of the models presented here indicate that it is possible to identify characteristics of individuals more likely to abrogate their enlistment contract. Several factors-- DEP length, age, AFQT score-- are found to affect significantly the probability of becoming a DEP loss. However, the impact of age and AFQT on DEP loss are not as hypothesized. The impact of DEP length on DEP loss is consistent with the findings of other researchers.

Some factors are not significant while others have inconsistent signs across models. The interaction terms, for example, are not statistically significant. The results for the ACF and enlistment bonus participation are inconsistent. ACF and enlistment bonus participation have different signs in each model. Only one of these factors is statistically significant in each model, and it is different in each model.

Although some factors are identified which make it possible to differentiate between those most likely to be DEP loss and those who are not, further research is needed. Factors such as, whether or not an individual received his MOS choice, the MOS contracted for, labor market condition of the recruiting battalion from which the individuals enlisted, and indicators of the recent employment history of the recruit needed to be investigated. Some of these factors, MOS choice and indicators of recent employment history, will require considerable resources to develop. The unemployment rate of the recruits' community, an

indicator of labor market conditions, can be readily incorporated into the model. This will be the next extension of the model to be developed.

Table 1: DATA SET CHARACTERISTICS

VARIABLE	VALUE	N=87,997 FY86	N=73,233 FY87
DEP LOSS	RATE	.084	.096
AGE	MEAN	20.60	20.00
AFQT SCORE	MEAN	70.96	70.90
DEP LENGTH	MEAN	4.84	4.88
EDUCATION	SENIOR	35.09	36.19
	HSDG	64.91	63.81
ACF PARTICIPANT	YES	50.96	40.74
	NO	49.04	59.26
BONUS	YES	35.25	19.71
	NO	64.75	80.29
DEPENDENTS	YES	11.59	11.73
	NO	88.41	88.27
TERM	2	18.42	19.71
	3	35.25	37.98
	4	46.33	42.31
BRIGADE	1	20.30	19.22
	3	18.76	18.76
	4	16.58	18.41
	5	26.51	26.17
	6	17.85	17.44

Table 2: Results of FY86 Model

VARIABLE	BETA	STD. ERROR
INTERCEPT	-12.62157636	0.58935582*
AGE	0.42166862	0.04873577*
AGESQ	-0.00593065	0.00102466*
DEPL	0.34949978	0.02479997*
DEPLSQ	-0.00140463	0.00204794
AFQT	-0.00526302	0.00096064*
EDUC_SEN	0.54712770	0.17966037*
ACF_YES	-0.12023994	0.02982727*
BONUS_YES	-0.02176872	0.03803013
DEPEND_NO	3.03178642	0.13719091*
TERM_3	-0.10834649	0.03658906*
TERM_2	0.19387014	0.04729645*
DL_EDSEN	-0.07074911	0.04966312
DLSQ_EDS	-0.00242085	0.00329136
BGD3	-0.06071777	0.03949923
BGD4	-0.22860344	0.04359430*
BGD5	-0.16570408	0.03562018*
BGD6	-0.11592479	0.04017782*

FRACTION OF CONCORDANT PAIRS OF PREDICTED PROBABILITIES AND RESPONSES: 0.74
R= 0.35
MODEL CHI-SQUARE= 6264.53 WITH 17 D.F.
(-2 LOG L.R.) P=0.0

Table 3: Results of FY87 Model

VARIABLE	BETA	STD. ERROR
INTERCEPT	-10.33052362	0.59823561*
AGE	0.39118793	0.05033243*
AGESQ	-0.00562571	0.00105548*
DEPL	0.32523460	0.02622246*
DEPLSQ	-0.00101560	0.00218182
AFQT	-0.00473684	0.00097990*
EDUC_SEN	0.56351833	0.17918602*
ACF_YES	0.05126007	0.03541310
BONUS_YES	0.10656330	0.03871964*
DEPEND_NO	1.35864041	0.07067447*
TERM_3	-0.11841061	0.03447298*
TERM_2	0.01086311	0.04612770
DL_EDSEN	-0.03864572	0.05111070
DLSQ_EDS	-0.00543839	0.00346847
BGD3	-0.09698671	0.04104301**
BGD4	-0.32158930	0.04534624*
BGD5	-0.11583810	0.03664341*
BGD6	-0.16836379	0.04218739*

FRACTION OF CONCORDANT PAIRS OF PREDICTED PROBABILITIES AND RESPONSES: 0.72
R= 0.32
MODEL CHI-SQUARE= 4614.86 WITH 17 D.F.
(-2 LOG L.R.) P=0.0

FIGURE 1: DEP LOSS PROBABILITIES

GSMA CONTRACTS (FY86)

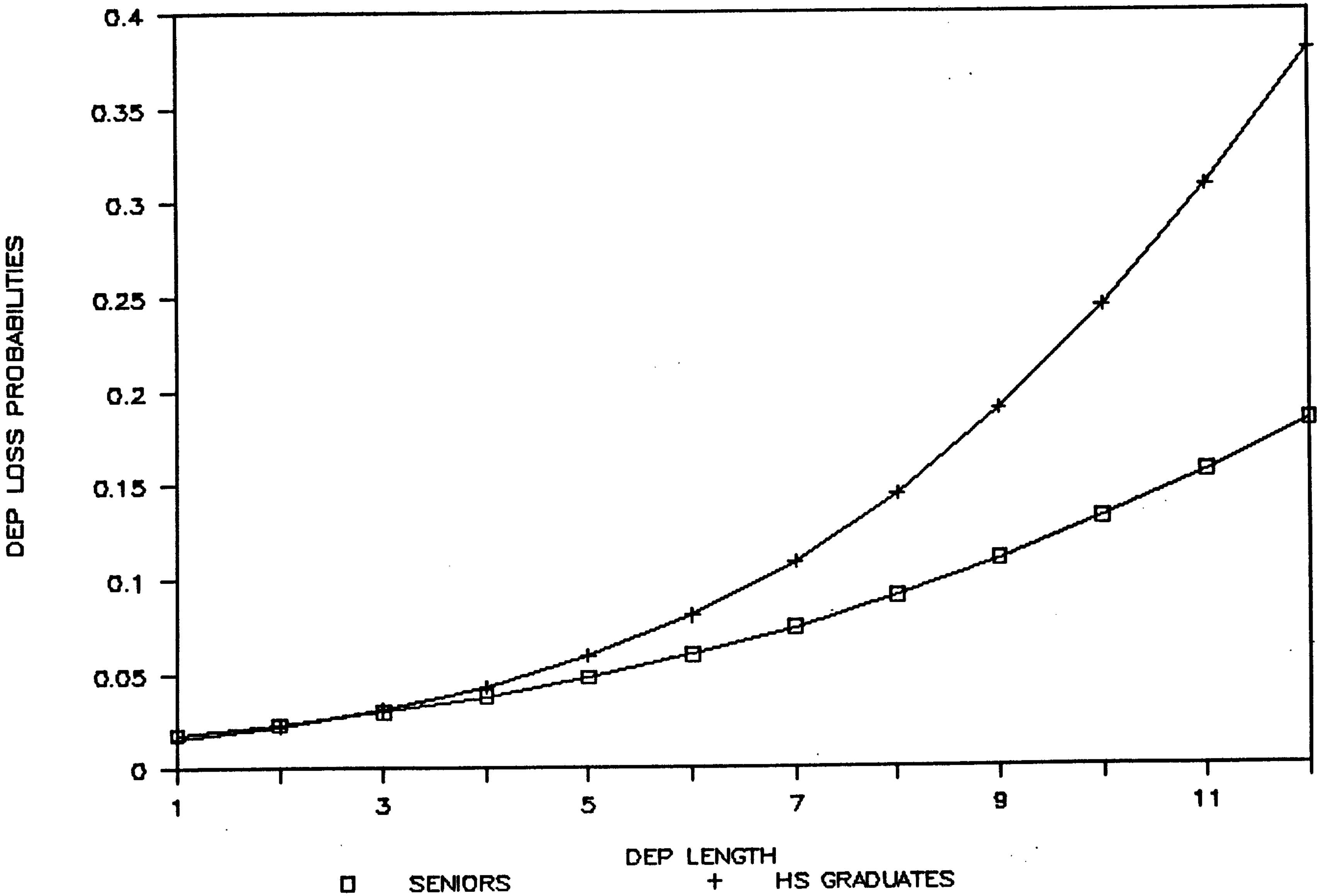


FIGURE 2: DEP LOSS PROBABILITIES

GSMA (FY87)

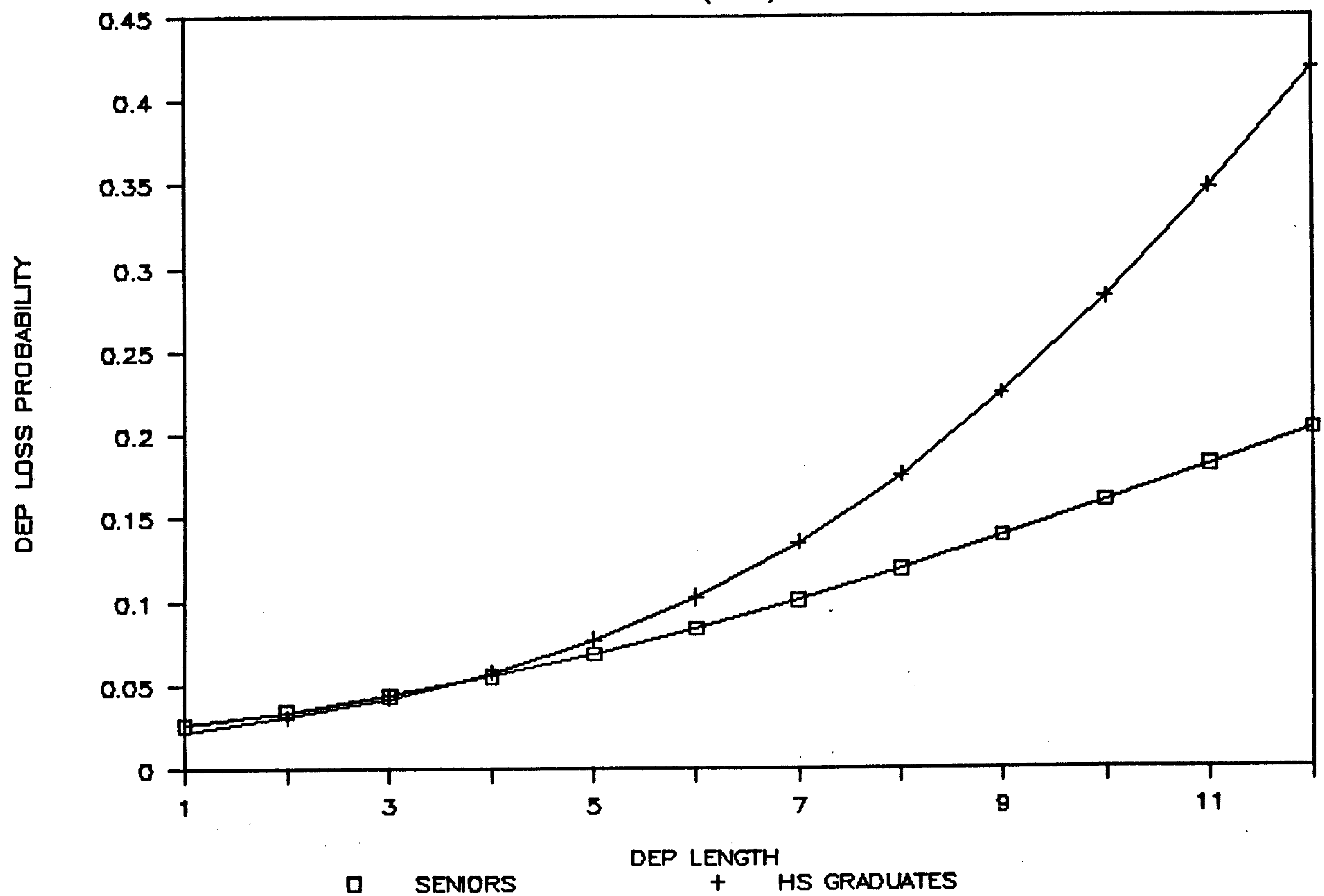


FIGURE 3: DEP LOSS PROBABILITIES

GSMA CONTRACTS (FY86)

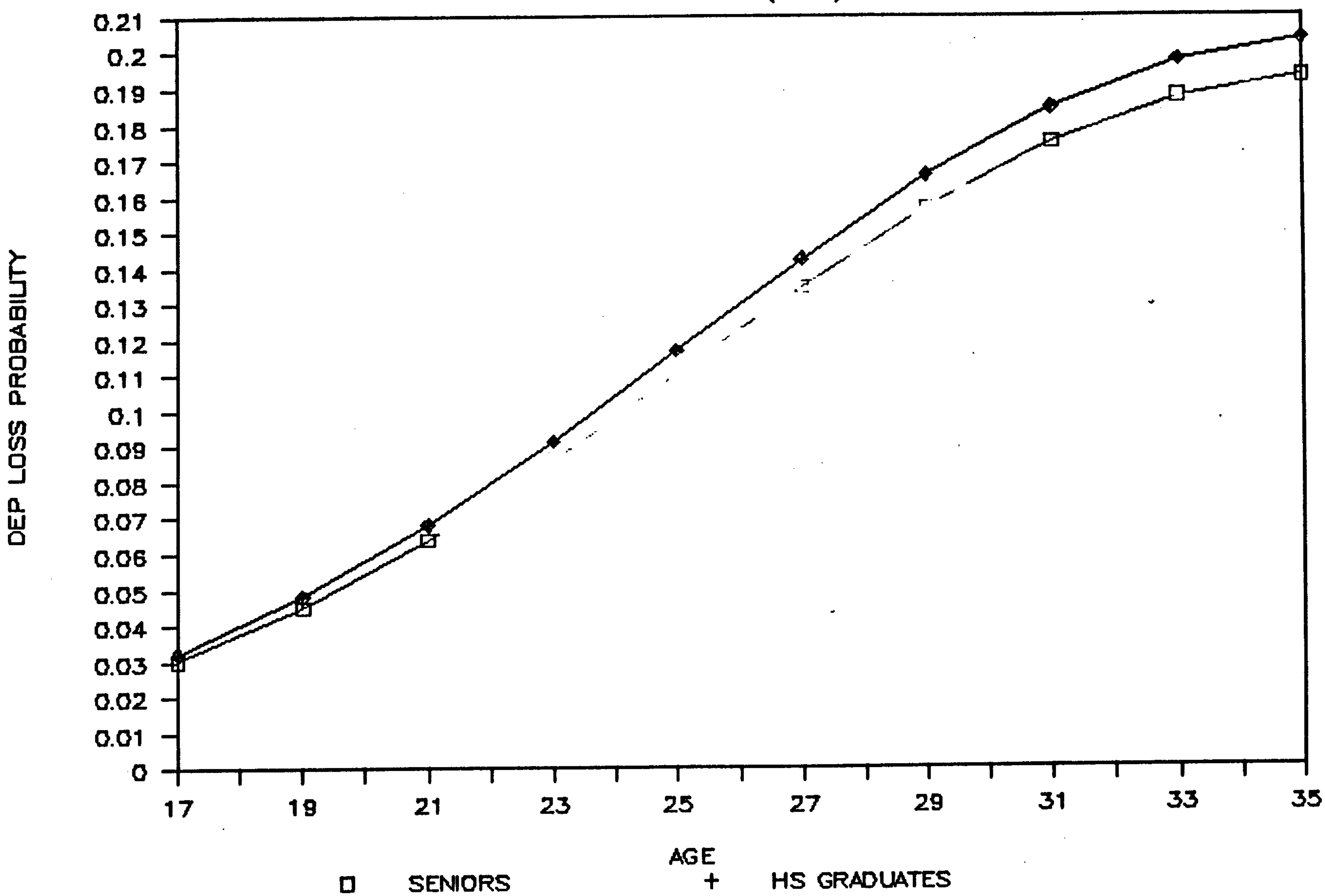


FIGURE 4: DEP LOSS PROBABILITIES

GSMA CONTRACTS (FY87)

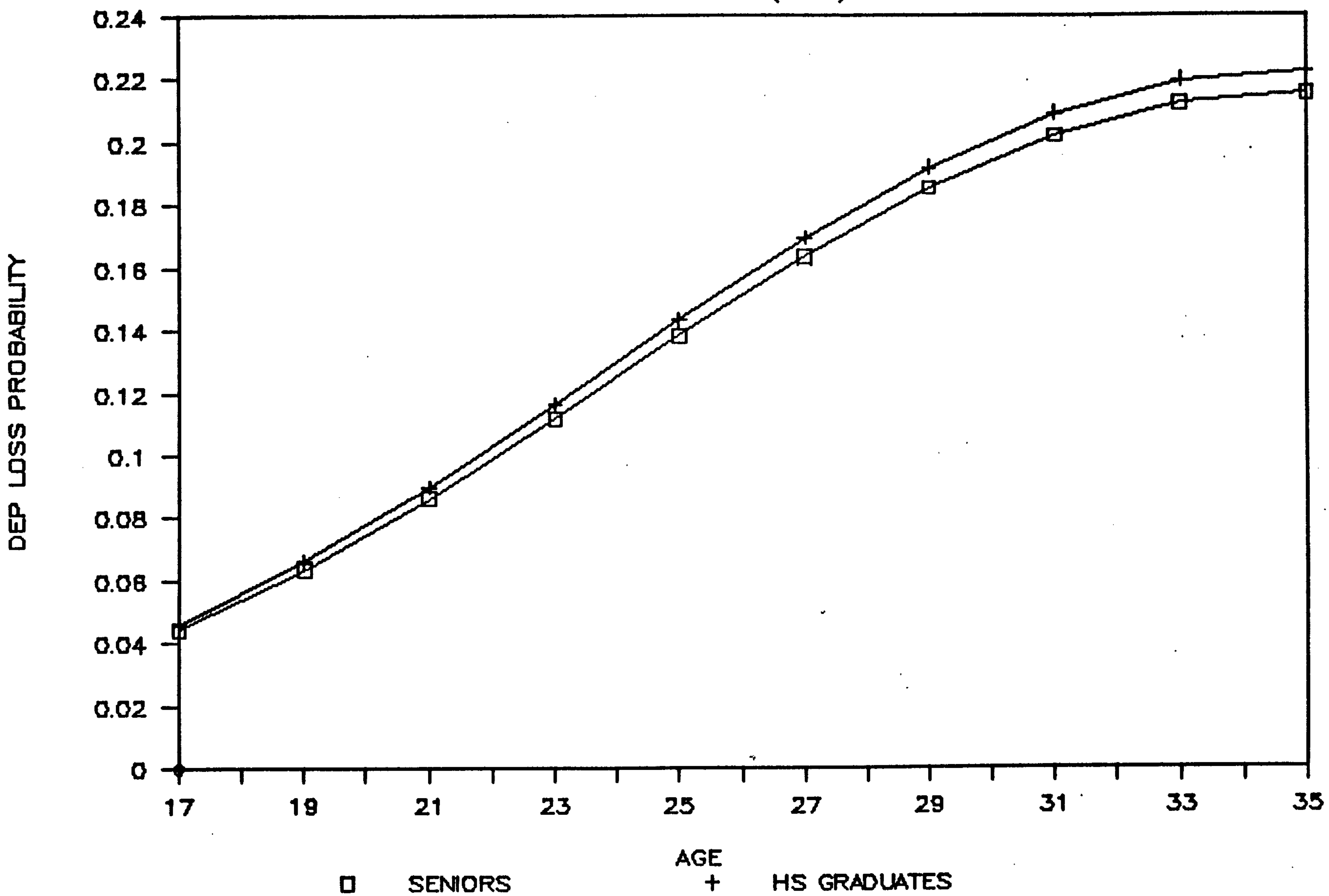


FIGURE 5: DEP LOSS PROBABILITIES

GSMA CONTRACTS (FY86)

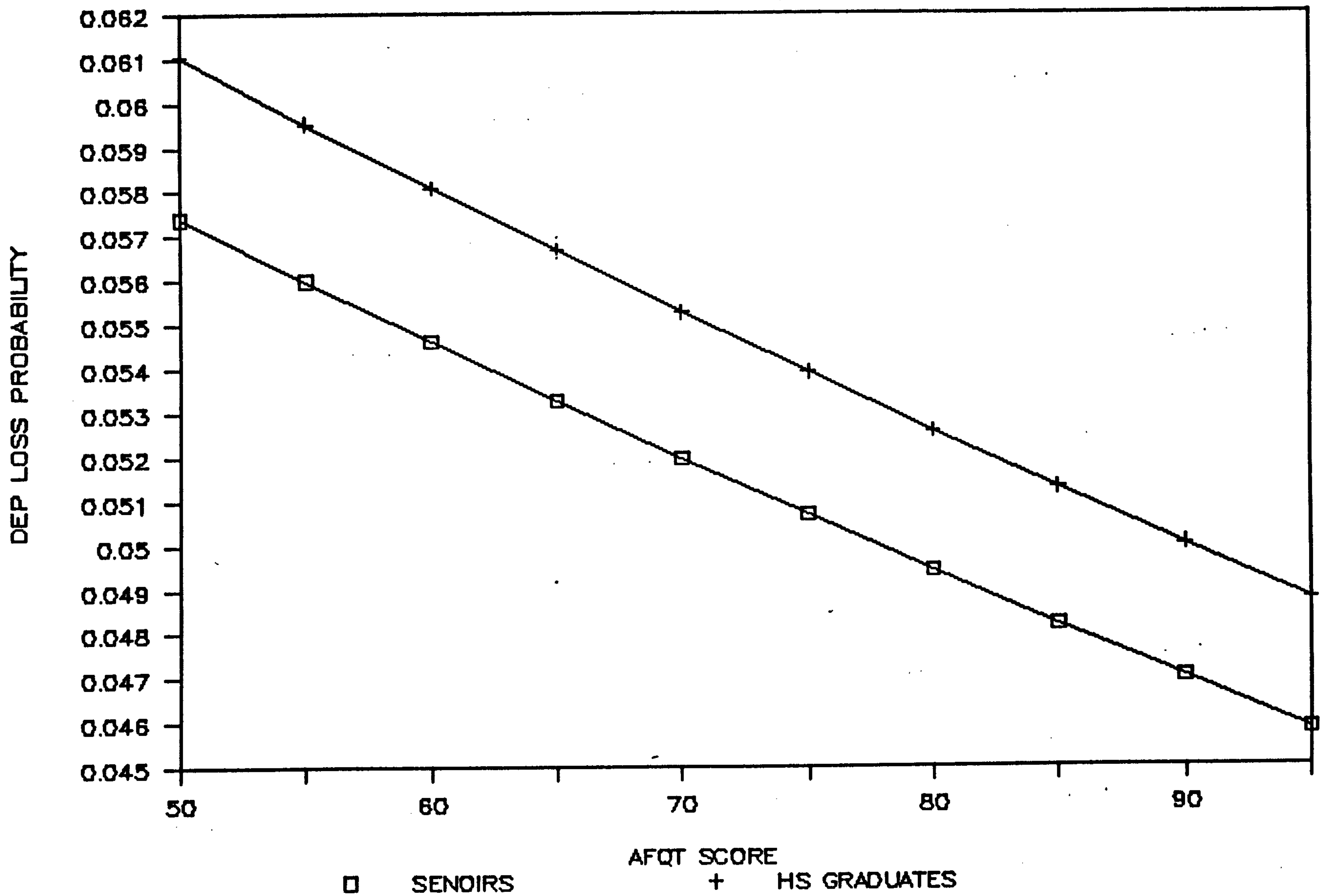


FIGURE 6: DEP LOSS PROBAIBLITIES

GSMA CONTRACTS (FY87)

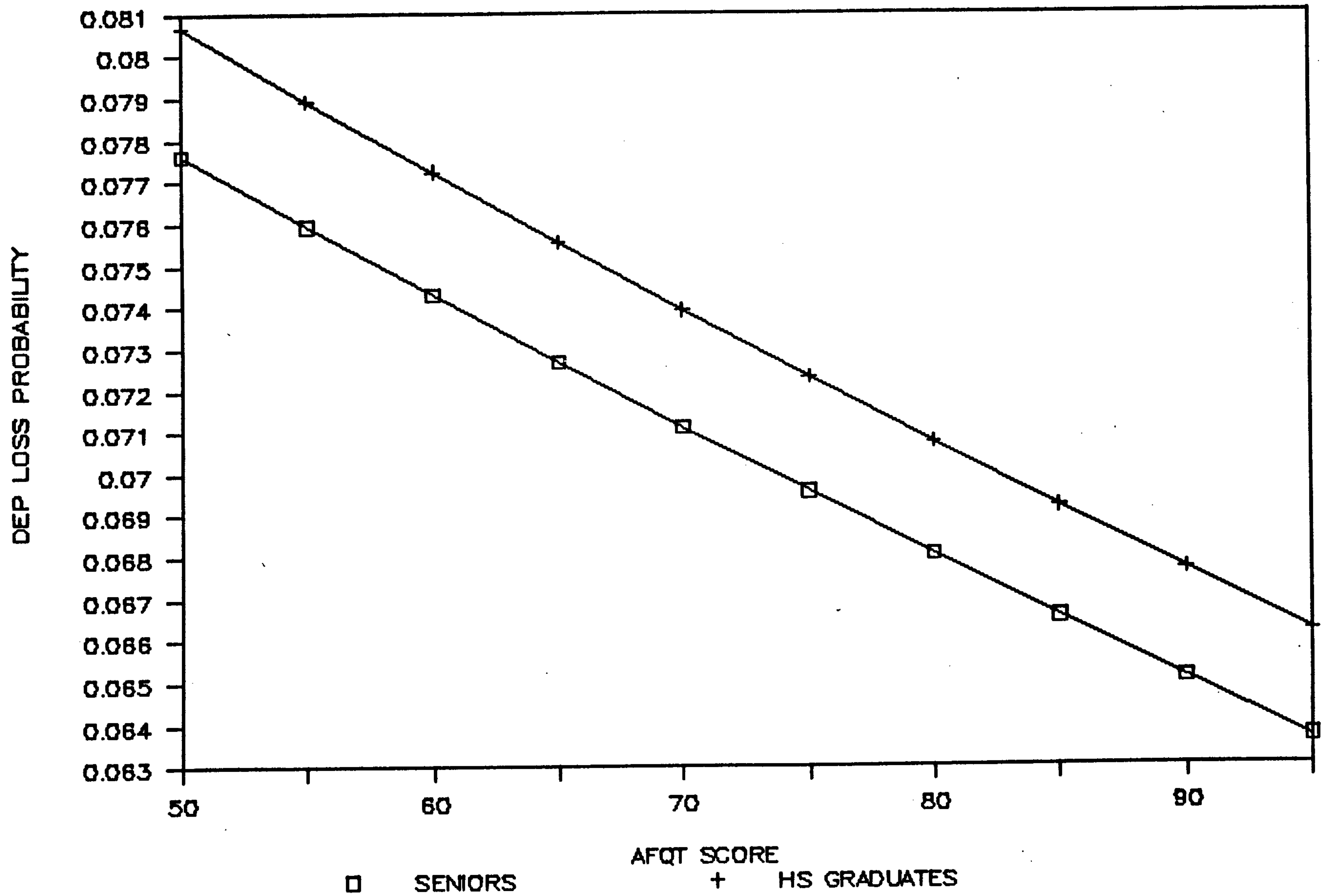


FIGURE 7: DEP LOSS PROBABILITIES

HIGH SCHOOL GRADUATES (FY86 AND FY87)

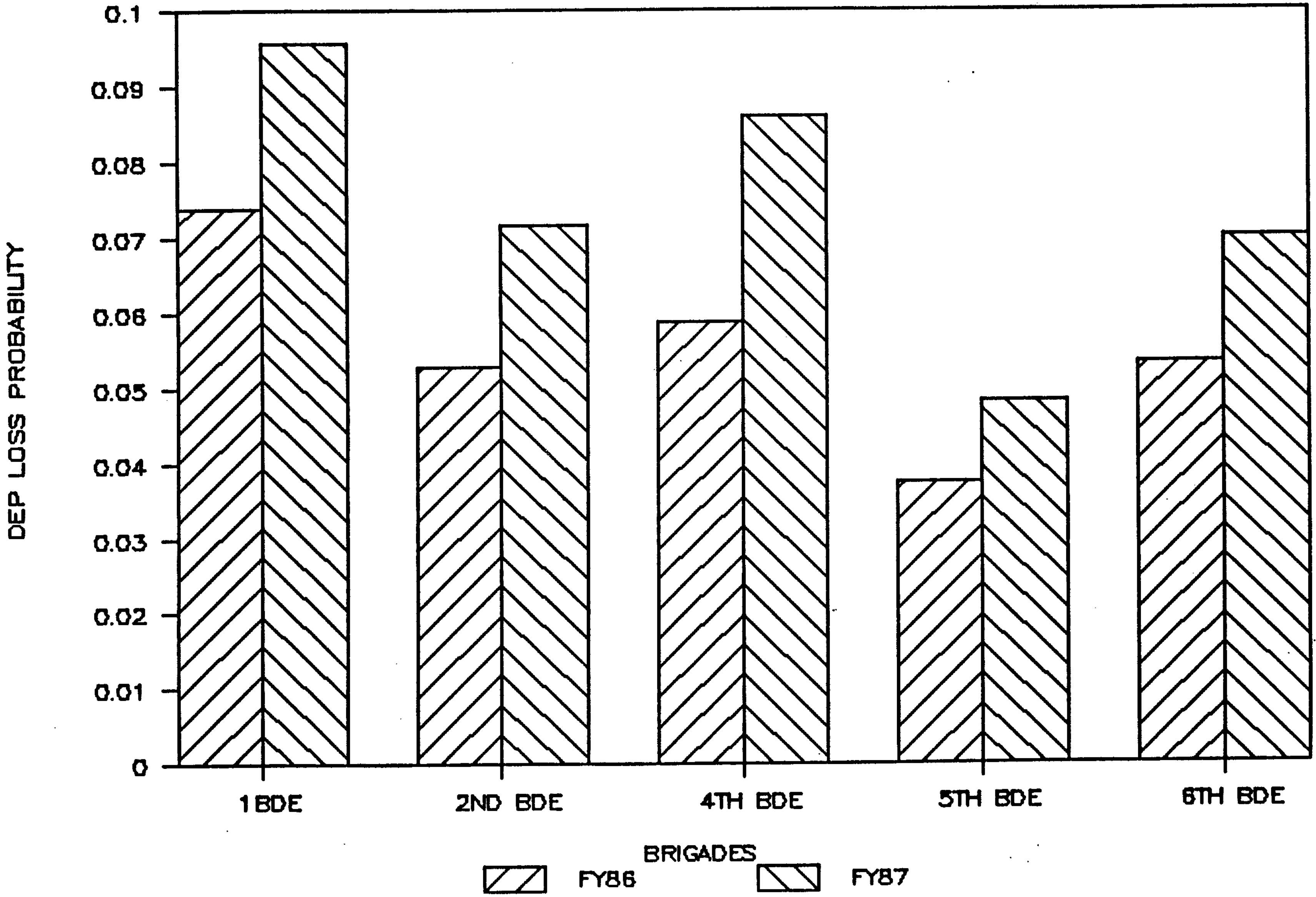
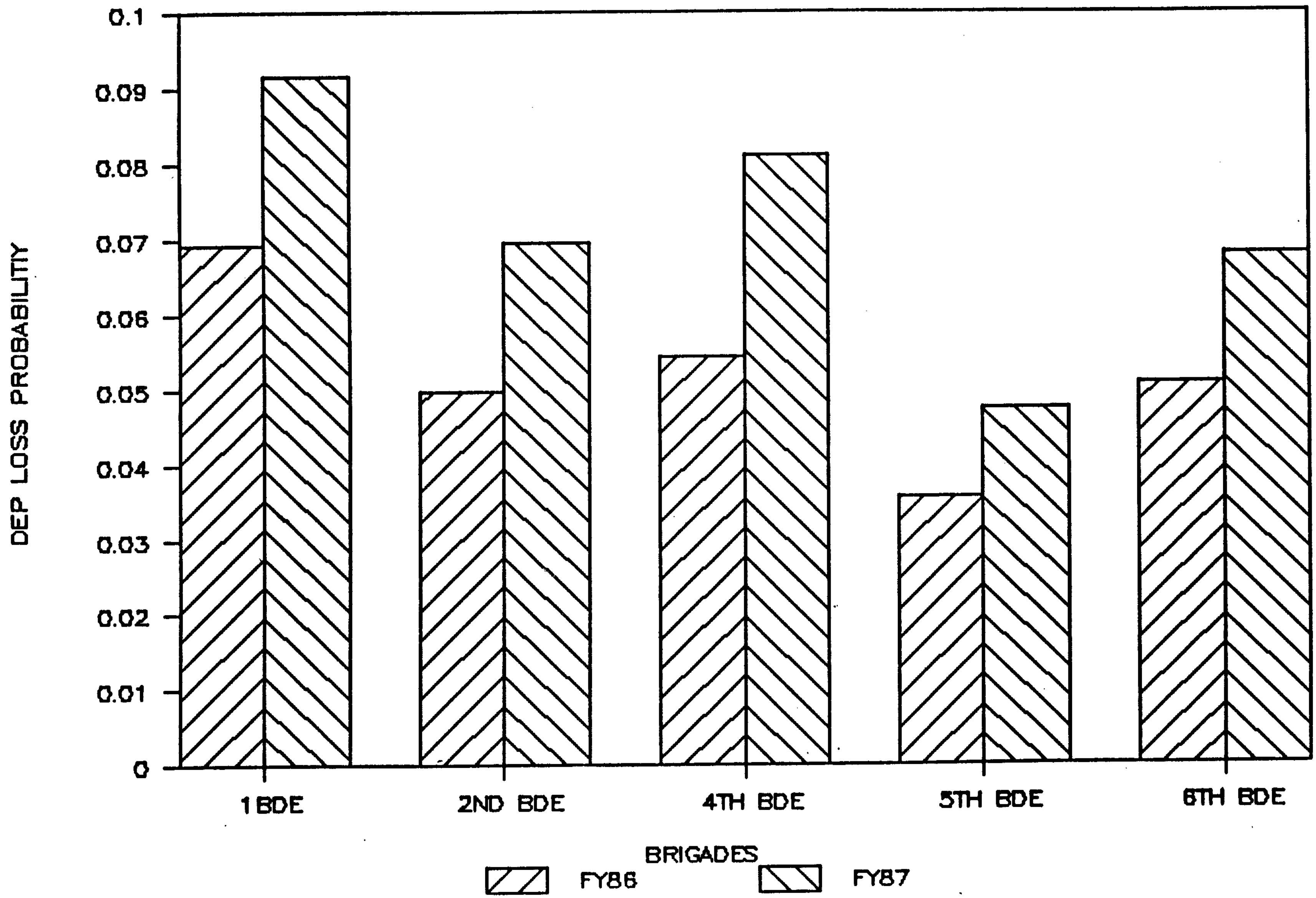


FIGURE 8: DEP LOSS PROBABILITIES

HIGH SCHOOL SENIORS (FY86 AND FY87)



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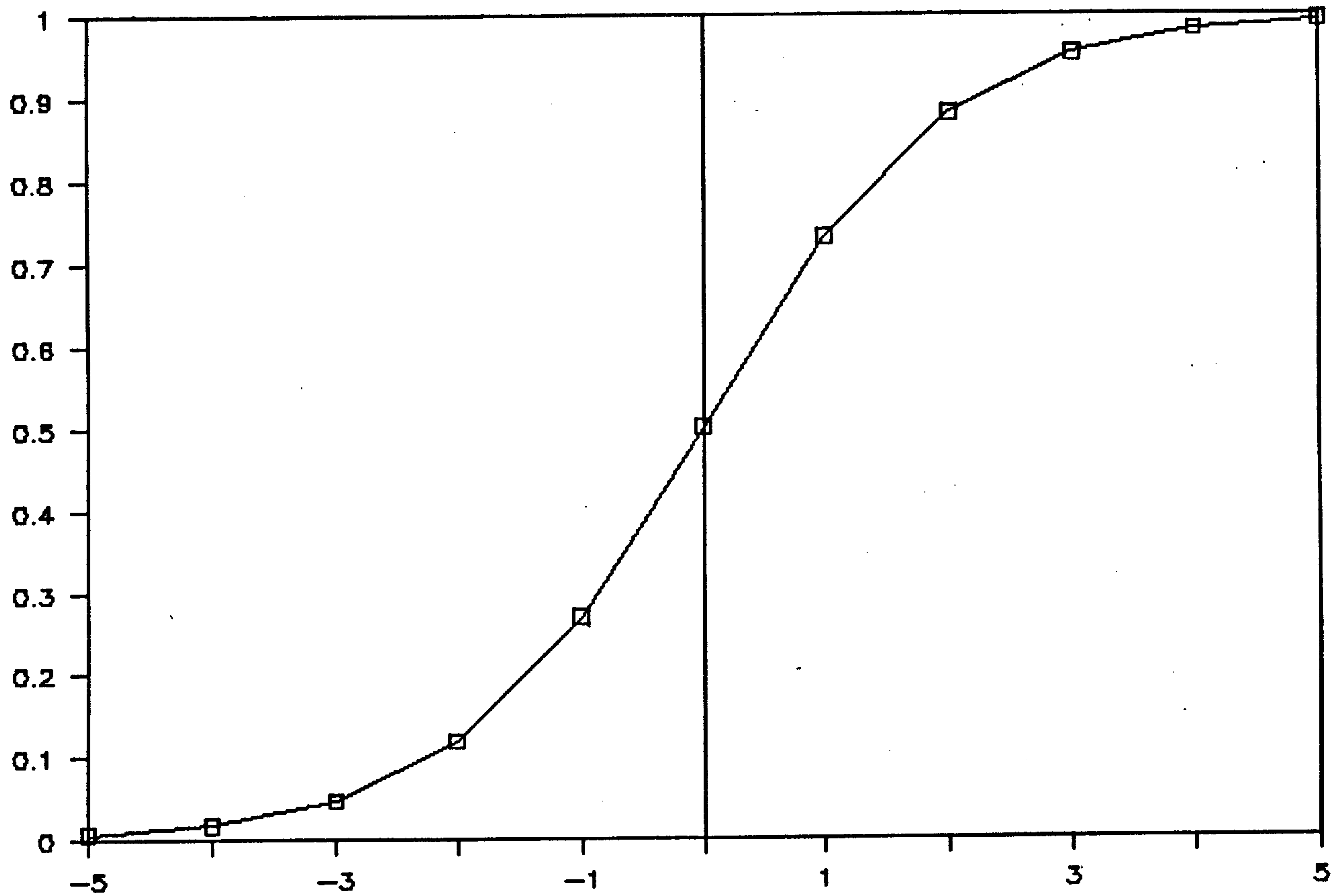
Quester, A. and Murray, M. S. (1986). Attrition from Navy Enlistment Contracts. Center for Naval Analysis Memorandum 86-12, January 1986.

APPENDIX A

LOGISTIC DISTRIBUTION



APPENDIX B

MEANS OF FACTORS FOR FY86 AND FY87 BY BRIGADE

BRIGADE 1

VARIABLE	FY86	FY87
DEP LOSS	0.10000560	0.11553757
AGE	19.88908165	19.71566539
AFQT SCORE	71.42738821	71.22518108
DEP LENGTH	5.09871845	5.29654879
SENIORS	0.37903632	0.41989774
ACF YES	0.48816386	0.40164749
BONUS YES	0.30219934	0.17419401
NO DEPENDENTS	0.92982260	0.93168584
TERM 2	0.19760479	0.21389007
TERM 3	0.36504561	0.37494674

BRIGADE 3

VARIABLE	FY86	FY87
DEP LOSS	0.08214697	0.09296738
AGE	20.00720906	19.95457193
AFQT SCORE	69.53868056	69.47240827
DEP LENGTH	4.67619798	4.70529994
SENIORS	0.35009390	0.35760047
ACF YES	0.50578542	0.37936808
BONUS YES	0.37741564	0.21665696
NO DEPENDENTS	0.86799540	0.86517181
TERM 2	0.18010541	0.19867501
TERM 3	0.32458957	0.35439720

BRIGADE 4

VARIABLE	FY86	FY87
DEP LOSS	0.06573896	0.06639958
AGE	20.54764190	20.64908376
AFQT SCORE	70.69817658	70.48401217
DEP LENGTH	4.29414587	4.02396320
SENIORS	0.27070195	0.25016693
ACF YES	0.50205648	0.37510201
BONUS YES	0.39402248	0.23102604
NO DEPENDENTS	0.82197697	0.81126196
TERM 2	0.16397039	0.16062022
TERM 3	0.34480395	0.39045923

BRIGADE 5

VARIABLE	FY86	FY87
DEP LOSS	0.08668067	0.10593331
AGE	19.81489261	19.65897824
AFQT SCORE	71.38418999	71.40374680
DEP LENGTH	5.21151455	5.42013255
SENIORS	0.38620483	0.41517508
ACF YES	0.51313928	0.43140427
BONUS YES	0.33013246	0.18196525
NO DEPENDENTS	0.89381404	0.90283359
TERM 2	0.20992841	0.22449512
TERM 3	0.34209285	0.36826175

BRIGADE 6

VARIABLE	FY86	FY87
DEP LOSS	0.08137018	0.09089486
AGE	20.21157519	20.20355437
AFQT SCORE	71.53673755	71.78478040
DEP LENGTH	4.64707755	4.69842637
SENIORS	0.34273526	0.34024896
ACF YES	0.53998472	0.44218273
BONUS YES	0.36903094	0.18860096
NO DEPENDENTS	0.89207946	0.89250763
TERM 2	0.15363555	0.17411728
TERM 3	0.39036037	0.41846082

Manpower and Personnel Policy Research Group

Working Paper MPPRG 90-06

ALLOCATIVE IMPACTS OF ENLISTMENT INCENTIVES

ABRAHAM NELSON

28 SEPTEMBER 1990

FOR ARI INTERNAL DISTRIBUTION

Approved by:

Curtis L. Gilroy
Chief, Manpower and Personnel
Policy Research Group

MANPOWER AND PERSONNEL RESEARCH LABORATORY

U.S. ARMY RESEARCH INSTITUTE
FOR THE BEHAVIORAL AND SOCIAL SCIENCES
5001 Eisenhower Avenue, Alexandria, VA 22333-5600

INTRODUCTION

The contemplated force reductions will impact the Army's recruiting missions. Unquestionably this will result in fewer recruiting resources. The Army will come under pressure to reduce all of its enlistment incentives programs. In such an environment, the necessity for efficient allocation and management of scarce recruiting resources becomes an imperative for the Army.

The objectives of this research effort are twofold. First, to determine the impact of the Army College Fund (ACF) and the enlistment bonus program on enlistments at the military occupational specialty level. These programs are used to both entice certain individuals to enlist and to channel them into specific Army jobs. Such programs also have an impact on term of enlistment. Estimates of these impacts are both valuable in themselves and also essential to accomplishing the second objective.

The second and primary objective of this effort is to develop of a methodology which can be used to assist Army decision makers in their planning for the ACF and enlistment bonus programs. The methodology will enable Army decision makers to perform cost-effectiveness analysis and to examine tradeoffs. It will assist them in answering questions such as:

- How much should be paid for the enlistment bonus?
- How large should the Army College Fund (ACF) be?
- How should the budget be allocated between the ACF and the enlistment bonus programs?
- Which MOS should receive the ACF or the bonus?

Our approach is to combine estimates of market expansion, skill channeling, and term of enlistment effects of the ACF and enlistment bonuses along with the costs of programs. We then use a mathematical program to select a set of recruiting incentives so as to minimize cost or optimize some other objective at the skill level of detail. In section 2 of this paper we describe the ACF and the enlistment bonus programs. In section 3 we present the methodology for estimating the impact of the programs. Some preliminary results are also presented in this section.

BACKGROUND

The Army uses incentives to entice high quality recruits to enlist and to channel them into hard-to-fill military occupational specialties (MOS). Such recruiting incentives can also shift high quality recruit's terms of enlistment. The major economic incentives, the ACF and enlistment bonuses are available to high school diplomas graduate scoring in fiftieth percentile on the Armed Forces Qualification Test (AFQT). The Army regards these individuals as high quality recruits. The justification for attempting to recruit as many high quality individuals is the hypothesis that they are more productive and more difficult to recruit than other individuals.

The Army has used educational benefits since 1979 to induce high quality individuals to enlist. The current educational benefit program, the Army College Fund, is a contributory program which has been an important tool since fiscal year 1982 (FY82). The current version of the ACF is based on the New GI Bill, which replaced the Veteran's Educational Assistance Program in FY85. This program allows the participating recruit to contribute $1,200 over the first year of service. This entitles the enlistee to $10,800 of educational benefits for those enlisting for three or four years, and $9,000 for those enlisting for two years. Individuals who enlist in program-eligible MOS also receive supplemental educational benefits, referred to as kickers. Currently the recruit who enlisted for the ACF can use the benefits only after completion of service. This program expands the recruiting market and channels enlistees into hard-to-fill MOS.

Enlistment bonuses are the other form of compensation used by the Army to entice high quality recruits to enlist into and hard-to-fill MOS. Bonuses are flexible since they can be added or deleted at any time without affecting other elements of the compensation package. Bonuses are also less costly than general pay increases, since the recipients are only those individuals enlisting in hard-to-fill MOS. A bonus recipient receives 50 percent of the bonus after the completion of training and the remainder in equal annual payments. The average enlistment bonus received in FY88 was $3,620.

As noted earlier, the Army College Fund and the enlistment bonus program expand recruiting markets, channel recruits into specific MOS, and shift terms of enlistment. There have been several research efforts to estimate the effects of the ACF and enlistment bonuses. Most efforts, however, have focused only on the market expansion effects of these incentives. Limited research has been done on the skill channeling and the term shifting effects of these incentive programs. It is essential to consider all aspects of programs when allocating them across MOS.

In FY81 the Office of the Secretary of Defense requested that an experiment be conduced to investigate the effectiveness of various educational benefit programs. Fernandez (1982) performed the analysis on the resulting experimental data. He found Ultra-VEAP (Veteran Educational Assistance Program), a program with a maximum benefit of $17,400, to be the most successful in attracting high quality recruits. Ultra-VEAP is the predecessor of the Army College Fund. Fernandez estimated an elasticity of .16 for this program. Daula and Smith (1985) also estimated that education benefits in the form of the ACF is .16.

These analyses focused only on the market expansion effect of the educational benefit programs. Schmitz (1989) estimated not only a market expansion effect but also and term shifting effect of the ACF. He found that while the Army College Fund increased enlistments by 9 percent over Super VEAP, it also reduced the proportion of four-year enlistments.

Other researchers have also estimated the enlistment supply or market expansion effect of the ACF and enlistment bonuses. A summary of investigations of the ACF market expansion effects is provided in Schmitz (1989). He reported these estimates in terms of percent enlistment gain relative to enlistment during the Super VEAP (maximum benefits of $11,400 - kickers or $2,000 for a two-year enlistment, $4,000 for a three-year enlistment, and $6,000 for a four-year enlistment) era. Schmitz found that Brown (1983) predicted the largest increase in enlistments, 102% and Goldberg and Greenston (1986) the smallest, an increase of .2%.

The market expansion effect of enlistment bonuses has also been estimated by other researchers. Since most Army enlistment supply models include wages as a variable, and bonuses augment wages, then one can employ the wage elasticity to estimate the impact of bonuses. Fernandez (1979) reported wage elasticities from .54 to .88. Dale and Gilroy (1983) reported a pay elasticity of 2.3 for all nonprior service male high school graduates (all test categories).

Responding to a mandate from Congress, the Department of Defense and the Army conducted an experiment from July, 1982 through June, 1984, to determine the effects of bonuses on enlistments. Polich, Dertouzos, and Press (1986) examined the impact of various enlistment bonuses programs. They estimated market expansion, skill channeling, and term of enlistment shifting effects of enlistment bonuses. For example, they found that increasing the existing bonus by $3,000 had the following effects:

Market expansion: A 4.1% increase in high quality contracts.

Skill channeling: A 31.7% increase in test-eligible skill contracts.[1]

Term of service: A 15.3% increase in four-year terms.

Few other researchers have examined the skill channeling effects of the ACF and enlistment bonuses. One of the few, Fernandez (1982) found that the ACF increased high quality enlistments in eligible MOS without adversely impacting others. Schmitz (1989) also found results suggesting that ACF impacts on MOS choice.

Even less research has been done on the effects of enlistment incentives on choice of enlistment term. The Polich et al. (1986) effort is one of the few investigating term of service choice behavior. They examined experimental bonus programs relative to the one in place prior to July 1982 and found, for example, that when bonuses were increased by $3,000 for four-year terms, enlistments increased four-year terms by 15.3 percent and decreased by 28.5 percent three-year terms.

The New Recruit Survey, which is conducted by the U.S. Army Research Institute for the Behavioral and Social Sciences, provides information suggesting the market expansion and skill channeling effects of the ACF and bonuses. For example, the following question is on the survey: Suppose the job you signed up for did not pay a cash bonus. What would you have done?

Answer options make it possible to infer skill channeling and market expansion effects. Table 1 presents results from the New Recruit Survey of these effects from FY83 through FY88. Note that in all instance, except one, the skill channeling effect is the larger of the two.

There have been several models developed for application to particular aspects of incentive management. For example, Grissmer and Fernandez (1986) built an equilibrium, deterministic, nonlinear programming model for minimizing the cost of meeting manpower requirements. They included three types of equations to describe the enlistment process: cost equations, enlistment supply equations, and occupational choice equations. Their costs included:

- The marginal processing cost per recruit
- The marginal cost of an additional recruiter
- The actual costs of enlistment bonus programs

---

[1]Test-eligible MOS are 05H, 11X,13B,13E,13F,15E, and 19A.

Table 1

The Effect of Enlistment Bonuses -New Recruit Survey

	Skill Channeling	Market Expansion
FY83		
Fall	7.1	5.1
Spring	7.4	6.9
FY84		
Fall	13.2	13.5
Spring		
FY85		
Fall	14.3	11.8
Spring	13.6	11.9
FY86		
Fall	12.8	11.1
Spring	12.7	11.3
FY85		
Fall	17.5	6.3
Spring	19.2	6.6
FY86		
Fall	13.0	9.4
Spring	12.3	13.2

o The accrual costs of educational benefit programs.

Grissmer and Fernandez's enlistment supply equations took the form of a separate equation for each occupational specialty, and included unemployment rates, basic pay, enlistment bonuses, educational benefits, and the number of recruiters. Their policy variables included number of recruiters, the enlistment wage level, enlistment bonuses, educational benefits, and the differential level of bonuses and educational benefits for each military occupational specialty (MOS) in the model.

The purpose of the Grissmer and Fernandez model was to determine the mix of policy variables that would in a least cost fashion fill multiterm manpower requirements. Their model considered both overall manpower requirements, such as end strengths and experience distributions, and also specialty requirements by term of service. Their prototype consisted of only two occupational specialties but could have been expanded to include any desired number. Their model focused on enlistee choices, and management options at accession, and the first, second, and third reenlistment points. A model with nonlinearities in both the objective function and the constraints requires far more complex and costly computer software than one with a linear objective function and linear constraints. Making

assumptions to create a linear model greatly simplifies the estimation of a model.

The Grissmer and Fernandez model was purely theoretical. While it could have been adapted to Army needs, they did not use any empirical data to measure the required model parameters or to validate their model.

Morey and Lovell (1987) did an exploratory analysis of monetary and nonmonetary incentives for Army recruiting. They constructed an MOS level model using quarterly data from the period FY81 through FY86. They minimized the costs of various combinations of incentive programs, using a translog cost equation that included quadratic interaction terms. They assumed that the total incentive cost for each MOS depended upon nine factors:

- The number of high quality enlistments in the MOS
- The high quality quotas outside that MOS
- The cost of each monetary incentive available
- Environmental variables, such as the unemployment rate and the military/civilian pay ratio
- The quarter
- The year
- The usage of nonmonetary incentives, such as permitting a soldier to choose his duty station
- The non-high quality quotas
- The levels of other Army resources being expended, such as advertising.

Morey and Lovell disaggregated Army enlisted manpower into 21 MOS's: 20 in the Combat Arms and a 21st grouping consisting of all other MOS's. They also restricted the coefficients in their regression equations to ensure that some parameters had the same value for all 21 MOS's: guidance counselor policy; non-high quality competitive effects; environmental variables, such as unemployment rates and advertising; and yearly and quarterly effects. Most of the explanatory power of their incentive cost equations were contained in two variables: the number of high quality contracts, and the ratio of the price of the ACF to the price of enlistment bonuses.

Morey and Lovell obtained some interesting results, but they were forced to make some questionable simplifying assumptions,

and they presented no operational system for implementing their model. For example, it is hard to imagine that guidance counselor reforms, non-high quality competitive effects, the effects of recruiting resources and environmental variables, and yearly and quarterly effects are the same for every MOS, as they assumed. The fact that those variables were not significant in their model, in contrast to many other studies, casts doubt on the validity of their underlying assumptions. In addition, neither their model nor the Grissmer and Fernandez model has a combination of an MOS level of disaggregation and a method for showing the effects of monetary incentives on transition rates that would be necessary for development of an Army total force incentive management model.

APPROACH

The objective in this effort is to develop a model that enhances the ability of either an analyst or a decision maker to manage the economic enlistment incentives, the ACF and enlistment bonuses, to meet personnel requirements in an efficient manner. Such a solution to this model will determine an incentive program to meet total manpower and quality requirements for the least cost. The objective is the cost-efficient utilization of recruiting resources.

To achieve this objective one needs estimates of the market expansion, skill channeling, and term of enlistment effects of the ACF and enlistment bonuses. One also requires estimates of the costs of training and attrition. Hence, attrition and retention rates are also needed.

The Skill Channeling Effect

Estimates of the skill channeling effects of the ACF and the enlistment bonus program are a prerequisite for the development of the incentive planning model. To examine the impact of these programs on MOS choice we employ the following equation:

$$(1)\quad logH_{it} = \alpha_{it} + \beta_1 \log\sum_{i=1}^{N} H_{it} + \beta_2 X_i + \beta_3 BONUS_i + \beta_4 ACFDUMMY_i + \epsilon_{it}$$

$$i=1,\ldots,N \text{ and } t=1,\ldots,T\ ,$$

where H_{it} is the number of high quality contracts enlisting in MOS i in time period t, X_i is the attributes of the i^{th} MOS, and ϵ_{it} is error term. This is a fixed effects model of the classical regression model.

Since the ACF and enlistment bonuses are designed to attract high quality personnel into specific MOS and terms of service, we expect them to increase the number of high quality recruits enlisting in MOS where they are available. We also expect larger bonuses to attract more high quality recruits than smaller ones. Therefore, we hypothesize that the coefficients on the variables associated with the ACF and enlistment bonuses are positive.

The Term of Enlistment Effect

Because of the scarcity of research on the impact of enlistment incentives on term choice it will be necessary to estimate this impact. A general equation which can be used to model the impact of enlistment bonuses on choice of enlistment term is (2) below. Controlling for MOS characteristics, X_i and the availability of ACF we can estimate the impact of MOS bonus allocation on proportion of high quality individuals enlisting in a MOS.

$$(2)\quad logH_{ity} = \alpha_{ity} + \beta_1 \log\sum_{i=1}^{N} H_{it} + \beta_2 X_i + + \beta_3 BONUS_i + \beta_4 ACFDUMMY_i + \epsilon_{ity}$$

$$i=1,\ldots,N \text{ and } t=1,\ldots,T$$

where H_{ity} is the number of high quality contracts enlisting in the i MOS in the t^{th} time period for y-year term of enlistment and ϵ_{ity} is the error term.

Again, a similar equation is employed to estimate the effects of ACF on term of enlistment choice.

RESULTS

The first stage of our analysis is concerned with the estimation of the skill channeling effect of enlistment incentives. The model estimated has the general form noted in the previous section. We use data from the FY83 through FY85 contract cohorts. Table 2 presents the characteristics of these cohorts.

These data were aggregated by MOS and time intervals, (quarters in this instance). Bonuses available to a MOS during each quarter are incorporated in to the data set. In addition other information characterizing the MOS, such as the number of training days and cost, aptitude area cut-score, and high school graduation and gender eligibility requirements, is also included.

Table 2:

Characteristics of enlistment cohorts for FY1983-85

Variable	FY83	FY84	FY85
Mental category I-IIIA	62.30	59.21	61.13
High School Graduates	92.01	95.45	90.69
I-IIIA High School Grads	56.56	55.85	52.01
Enlistment Bonus	12.67	17.25	21.89
Educational Benefit	37.01	21.80	16.98
E. Bonus & Educ. Benefit	10.46	9.11	10.30
Male	87.09	86.52	85.81
Number of Contracts	126147	115836	11786

We examined the impact of the availability of the Army College Fund and/or enlistment bonuses to a MOS on the quality composition of that MOS. The model, equation (3) below, is estimated using ordinary least square regression.

$$(3)\ \log\frac{H_{i,t}}{\sum_{i=1}^{N} H_{i,t}} = \beta_0 + \beta_1 EBDUMMY_i + +\beta_2 ACFDUMMY_i + \beta_3 Both_i + \epsilon_i$$

$$i=1,\ldots,N \text{ and } t=1,\ldots,T$$

Where H_{it} it the number or high quality recruits in MOS i in the t^{th} time period. Here N is 472 and T is 12. Table 3 presents the results of the estimation. These results suggest that the availability of enlistment bonuses and/or the ACF increase the high quality recruit in a MOS.

Table 3

The effect of the ACF and enlistment bonus on MOS choice

Variable	Coefficient	Std. Error
Intercept	-8.3838	0.17737
EBDUMMY	0.5500	0.05941
ACFDUMMY	1.0600	0.04311
EB & ACF	0.1997	0.07077

All variables are statistically significant the .01 level.

Interpreting of the coefficients of equation (3) requires the following transformation: $100(e^{\beta}-1)$, where β is the appropriate coefficient. This transformation indicates the percentage increase or decrease for each one unit increase in the independent variable.

Transforming the coefficients above we obtain 73.4, 418.2, and 22.1 for the enlistment bonus variable, the ACF variable, and the variable for the availability of both programs respectively. These results suggest, for example, that the availability of a bonus in a MOS increases the percent of high quality by 73 percent. The other coefficients can be interpreted in a similar manner. The ACF appears to have a much larger effect on MOS choice than the enlistment bonus and combining both programs adds an additional 22 percent. It can not be overemphasized, however, that these results are preliminary.

An alternative to the model above is to consider bonus levels, not merely their availability. Such an equation is very similar to (1).

The factors considered are the proportion total bonus dollars going to a MOS in a quarter, and whether or not the ACF is available in a MOS during a quarter. The equation also includes dummy variables for each MOS. The model, which is presented in equation (4), is referred to as a fixed effect model. Models of this type are used in the analysis of panel data, i.e. cross-sectional time series data. This is exactly the situation we have. Table 4 presents preliminary results from the estimation of this model. For the fixed effects their coefficients and their standard error are in the Appendix. Both the coefficients for bonus proportion and the ACF indicator variables are statistically significant and have the expected signs. These results suggest, for example, that if the proportion of enlistment dollars allocated to a MOS during a quarter increases then the percent of high quality individuals enlisting in that MOS increases. Further research is required in this area.

$$(4)\quad \frac{H_{i,t}}{\sum_{i=1}^{N} H_{i,t}} = \beta_{0,i} + \beta_1 \frac{BONUS_{i,t}}{\sum_{i=1}^{N} BONUS_{i,t}} + \beta_2 ACFDUMMY_{i,t} + \epsilon_{i,t}\,,$$

where i=1,...,N and t=1,...,T.

Table 4

The skill channeling effect of the enlistment bonus

Variable	Coefficient	Std. Error
RATIOBT	0.254111	0.0092348
ACFDUMMY	0.100002	0.018792

DISCUSSION

The development of a model to aid in the management of enlistment incentives is the primary objective of this research. This paper reports on the initial phases of this effort. First, a review of the relevant research, which may provide parameter estimates required in the incentive planning model, is presented. This is followed by a presentation of general approaches for the estimation of the skill channeling and term of enlistment shifting effects of the ACF and the enlistment bonus program. Next, a general description of a incentive planning model is presented. Preliminary estimates of alternative models of the skill channeling effects of enlistment incentives are then provided. This analysis indicates that both ACF and enlistment bonuses have strong skill channeling effects, as hypothesized.

Two steps are required to complete the development of the enlistment incentive planning model. The first is the estimation of the required parameters. This involves the development of behavioral models of the effects of the ACF and enlistment bonuses on recruits and models of the attrition behavior of soldiers. Although preliminary estimates of enlistment incentive effects were produced in this paper, further research is required.

As noted, estimates of the attrition behavior of soldier are required in the incentive planning model. A soldier becomes an attrition when he or she leaves the Army before the end of their obligated term of service. Probabilities of attrition will be estimated for each MOS using event history models. These separate attrition equations will be used to predict attrition and the associated cost.

The first developmental step also involves estimating cost parameters. Since recruiting costs will be a factor in the objective function of the incentive planning model, estimates of them are required. These costs include the cost of the ACF and enlistment bonus programs and other factors such as advertising and recruiter salary. Costs of recruiting both high and low quality individuals are needed. The primary source for MOS recruiting costs will be the AMCOS (Army Manpower Cost System) model.

In addition to recruiting costs, attrition costs will also be a factor in the objective function. These costs depend on the soldier's training MOS and career stage at which he or she becomes an attrition. Most recruits receive eight week of basic training. Upon the completion of this training, recruits receive either on-the-job or advanced individual training. Advance individual training can take from 7 weeks to a year to complete. If a recruit is an attrition during or after training, then the costs of training up to that point are lost. These costs may

include the cost of equipment and facilities and the wages and salaries of the recruits. We will assume that the cost of attrition is the cost of training as Nord and Kearl (1990) did.

The second step in the development of the enlistment incentive planning model will involve the specification of a model, which determines the "optimal" enlistment incentive program to achieve enlistment and quality requirements and meet second tour needs. The model objective, cost minimization, will be achieved within the Army organizational constrains, such the exclusion of females from the combat arms, behavioral constraints, and budgetary limitations.

During a soldier's tour of duty he or she makes several decisions. The primary ones are to:

- enlist
- select MOS
- select term of enlistment
- complete term of service
- reenlist.

The incentive planning model will consider all aspects of the process noted above. The outcome of the model will assist decision makers in determining which MOS should receive bonuses and/or the ACF.

Once these steps have been completed the development of the incentive planning model can proceed. Once d developed analyst can use it to project the impact of current incentive levels, and justify requirement.

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APPENDIX

Table A1

Fixed effects of enlistment bonuses

MOS	Coefficient	STD. Error
00B	0.00500	0.296177
00F	0.00633	0.170998
00J	0.07628	0.104715
00O	-0.03650	0.209640
01H	0.03108	0.085499
02B	0.06475	0.085499
02C	0.01518	0.089301
02D	0.01783	0.085499
02E	0.03033	0.085499
02F	0.02358	0.085499
02G	0.02064	0.089301
02H	0.01064	0.089301
02J	0.02433	0.085513
02K	-0.00275	0.104741
02L	0.03692	0.085499
02M	0.00750	0.104714
02N	-0.00245	0.089317
02S	0.02450	0.085499
02T	0.01360	0.093659
03B	-0.09600	0.296773
03C	0.09508	0.085513
05B	0.22312	0.210292
05C	1.58820	0.101632
05D	-0.02422	0.086684
05E	-0.09600	0.296773
05G	-0.00959	0.094585
05H	-0.06816	0.089365
05K	-0.04986	0.087586
05L	0.00000	0.296177
06B	0.00000	0.296177
09B	-0.10000	0.296773
09C	-0.09600	0.296773
09R	0.03533	0.098726
09S	0.56308	0.085556
09W	0.44042	0.085513
10P	0.00000	0.296177
11E	-0.09600	0.296773
11F	-0.06034	0.171456
11G	-0.09100	0.296773

MOS	Coefficient	Standard Error
11S	-0.09300	0.210270
11V	-0.09350	0.210270
11Y	-0.06150	0.148758
12B	1.06371	0.089962
12C	0.18012	0.087536
12E	-0.00881	0.090622
12F	0.05627	0.087539
12G	-0.09600	0.296773
12L	-0.04750	0.209640
12P	-0.09600	0.296773
12S	0.00000	0.296177
13B	0.83721	0.106488
13C	0.00266	0.087214
13D	-0.04800	0.209640
13E	0.04674	0.087881
13F	0.39209	0.090677
13G	0.00000	0.296177
13M	0.10514	0.087639
13R	0.03080	0.087214
13T	-0.10000	0.296773
13V	0.00200	0.209429
15B	-0.09500	0.296773
15C	-0.09600	0.296773
15D	0.21100	0.087819
15E	0.14385	0.088139
15F	-0.04500	0.209640
15J	0.00560	0.087536
15K	-0.09500	0.296773
15P	0.00000	0.296177
16A	0.00300	0.209429
16B	-0.04750	0.209640
16C	0.00400	0.296177
16D	-0.01629	0.148765
16E	0.06179	0.148768
16F	-0.04800	0.209640
16H	0.06633	0.087217
16J	-0.00917	0.086412
16K	-0.04750	0.209640
16L	-0.07222	0.148757
16P	0.15750	0.088240
16R	0.13691	0.087745
16S	0.20422	0.087923
16X	0.13658	0.089046
17B	0.03800	0.085499
17C	-0.01585	0.095173
17D	0.00500	0.296177
17K	0.05373	0.089360
17M	0.00500	0.089317
18C	0.00600	0.296177
18D	0.00000	0.296177
18E	0.00700	0.296177

MOS	Coefficient	Standard Error
19D	0.74488	0.091655
19E	0.00204	0.098748
19H	0.00000	0.296177
19K	0.05156	0.089673
19L	-0.09500	0.296773
21G	0.00262	0.087214
21L	0.05467	0.085513
22L	0.02100	0.296177
24C	0.08508	0.085513
24E	0.03283	0.085556
24G	0.09992	0.085513
24H	0.04700	0.085513
24J	0.04583	0.085513
24K	0.07217	0.085499
24L	0.03958	0.085513
24M	0.06383	0.085499
24N	0.03645	0.089301
24T	0.11342	0.085499
24U	0.04183	0.085513
24V	-0.03900	0.209640
24W	0.00933	0.170998
24Y	0.00800	0.296177
25L	0.01882	0.089317
26B	0.04225	0.104714
26C	0.04909	0.089317
26D	0.06290	0.093659
26E	0.03267	0.085499
26F	0.02200	0.093659
26H	0.03092	0.085499
26K	0.00850	0.209429
26L	0.15840	0.093735
26Q	0.30150	0.085513
26T	0.05033	0.085499
26U	0.00400	0.296177
26V	0.30125	0.085556
26X	0.00500	0.296177
26Y	0.23650	0.086653
27B	0.05900	0.085513
27E	0.20392	0.086199
27F	0.05158	0.085499
27G	0.04382	0.089301
27H	0.00900	0.209429
27L	0.01750	0.085499
27M	0.03992	0.085499
27N	0.02109	0.089317
27P	0.00671	0.111944
27Q	0.01100	0.170998
29E	0.12100	0.148089
29F	0.07925	0.148089
29G	0.01000	0.296177
29J	0.10480	0.132454

MOS	Coefficient	Standard Error
29M	0.09167	0.170998
29N	0.10440	0.132454
29S	0.07800	0.170998
31B	0.00400	0.296177
31C	1.00111	0.096006
31D	0.00500	0.209429
31E	0.23150	0.085513
31G	0.00500	0.296177
31H	0.00500	0.296177
31J	0.40942	0.085556
31K	0.75259	0.091753
31L	0.00600	0.296177
31M	1.89075	0.087540
31N	0.09117	0.085556
31P	0.00000	0.296177
31S	0.13409	0.089366
31T	0.06275	0.104741
31U	-0.09500	0.296773
31V	0.94040	0.087280
32D	0.21023	0.085790
32F	0.08400	0.098748
32G	0.08392	0.085499
32H	0.07818	0.089301
33D	0.00400	0.296177
33P	0.06538	0.104714
33Q	0.09425	0.104714
33R	0.04012	0.104714
33S	0.19029	0.111977
33T	0.08344	0.098726
34B	0.00450	0.209429
34C	0.00000	0.296177
34H	0.00400	0.296177
34L	0.07014	0.111944
34T	0.03725	0.148089
34Y	0.08333	0.085513
35C	0.04891	0.089301
35E	0.07917	0.085499
35F	0.01786	0.111944
35G	0.05825	0.085728
35H	0.15142	0.085556
35K	0.15225	0.085513
35L	0.06800	0.085513
35M	0.07600	0.089317
35R	0.04209	0.089301
36B	-0.10000	0.296773
36C	0.49498	0.086723
36D	0.01133	0.170998
36E	0.00325	0.148089
36H	0.23650	0.085513
36J	0.00000	0.296177
36K	0.86500	0.122366

MOS	Coefficient	Standard Error
36V	-0.09600	0.296773
39B	0.00500	0.296177
41B	0.01275	0.104714
41C	0.05325	0.085513
41E	0.00822	0.098726
41J	0.00083	0.120914
42C	0.01514	0.111944
42D	0.02633	0.085857
42E	0.01982	0.089317
43B	0.00000	0.296177
43D	0.00400	0.296177
43E	0.23079	0.085925
43F	0.00000	0.296177
43M	0.01116	0.085513
44B	0.13256	0.086013
44E	0.12600	0.085513
45B	0.07242	0.085556
45C	0.00500	0.296177
45D	0.01336	0.085856
45E	-0.03621	0.086652
45G	0.03042	0.085556
45H	-0.09600	0.296773
45K	0.15395	0.087537
45L	0.01764	0.086411
45M	-0.09600	0.296773
45N	0.04085	0.087219
45T	-0.00263	0.086013
46N	0.05575	0.085499
51B	0.17008	0.085499
51C	0.04183	0.085499
51G	0.00742	0.085556
51H	0.00000	0.209429
51K	0.05825	0.085499
51M	0.01833	0.085513
51N	0.07175	0.085513
51R	0.12025	0.085513
52C	0.27009	0.085856
52D	0.87393	0.088161
52F	0.01125	0.086013
52G	0.02518	0.089301
52L	0.00000	0.296177
52P	0.00000	0.296177
52V	0.00400	0.296177
53C	0.00000	0.296177
53D	0.00500	0.296177
53E	0.00200	0.209429
54B	0.00000	0.296177
54C	0.00899	0.086411
54D	0.00000	0.296177
54E	0.26561	0.087743
54F	0.00000	0.296177

MOS	Coefficient	Standard Error
54G	0.00000	0.296177
54H	0.00000	0.296177
54N	0.00000	0.296177
55B	0.15198	0.087537
55D	-0.01709	0.087224
55G	0.00266	0.086921
55K	0.00400	0.296177
55R	0.10033	0.085499
55V	-0.09600	0.296773
56Y	0.00400	0.296177
57E	0.02625	0.085513
57F	0.03183	0.085499
57H	0.09305	0.086411
59E	0.00000	0.296177
61B	0.08625	0.085513
61C	0.04208	0.085499
61F	0.00000	0.296177
61S	0.00000	0.296177
62B	0.25595	0.086660
62C	-0.04500	0.209640
62E	0.28218	0.086198
62F	0.08175	0.085556
62G	0.00292	0.085513
62H	-0.00109	0.089366
62J	0.14033	0.086412
62N	0.00200	0.209429
62S	0.00000	0.296177
62T	0.00500	0.296177
62W	0.00000	0.296177
62Y	0.00400	0.296177
63B	1.95846	0.090321
63C	-0.03167	0.171113
63D	0.12159	0.087544
63E	0.03066	0.086938
63F	0.00000	0.209429
63G	0.02882	0.087237
63H	0.21602	0.087342
63J	0.01749	0.087225
63K	0.00000	0.296177
63M	0.00000	0.296177
63N	0.16986	0.087313
63S	0.28190	0.087543
63T	0.32427	0.087366
63V	0.00000	0.296177
63W	0.34210	0.087840
63X	0.00000	0.296177
63Y	0.13420	0.086663
64B	-0.04350	0.209640
64C	2.45058	0.087540
64D	-0.04750	0.209640
64F	0.00000	0.296177

MOS	Coefficient	Standard Error
64W	0.00000	0.296177
64Y	-0.09500	0.296773
65C	-0.09600	0.296773
65G	0.00400	0.296177
65J	0.00700	0.296177
65T	0.00400	0.296177
65Y	0.00000	0.296177
67B	0.00000	0.296177
67C	0.00000	0.296177
67E	0.00000	0.296177
67G	0.06708	0.085513
67H	0.06108	0.085499
67J	0.00500	0.209429
67L	0.00500	0.296177
67M	0.00500	0.296177
67N	0.58250	0.085556
67R	0.13080	0.132454
67S	0.11100	0.296177
67T	0.30150	0.085513
67U	0.38067	0.085513
67V	0.53425	0.085556
67W	0.00250	0.209429
67X	0.00500	0.296177
67Y	0.47925	0.085513
68B	0.16525	0.085499
68D	0.13200	0.085499
68E	0.00400	0.296177
68F	0.15433	0.085628
68G	0.28050	0.085556
68H	0.09550	0.085513
68J	0.19483	0.085499
68M	0.11150	0.085513
68U	0.00500	0.296177
71C	-0.04350	0.148386
71D	0.28008	0.085857
71E	0.00500	0.296177
71G	0.14942	0.085556
71K	0.00333	0.170998
71L	3.10883	0.087540
71M	0.20650	0.086921
71N	0.08000	0.085728
71P	0.14522	0.098924
71Q	0.18083	0.085556
71R	0.02967	0.085728
71W	-0.04500	0.209640
71Y	0.00000	0.296177
72C	-0.09600	0.296773
72E	0.89478	0.087864
72F	0.00000	0.296177
72G	0.67275	0.087540
72H	-0.09500	0.296773

MOS	Coefficient	Standard Error
72J	0.00400	0.296177
72L	-0.09550	0.210270
72R	-0.04800	0.209640
72S	0.00000	0.296177
73B	0.00000	0.296177
73C	0.31800	0.085556
73D	0.09858	0.085499
73W	0.00500	0.296177
73Y	-0.09600	0.296773
74A	0.00700	0.296177
74C	-0.09600	0.296773
74D	0.23392	0.085513
74F	0.28742	0.085499
75B	0.66067	0.086014
75C	0.25933	0.085513
75D	0.39400	0.085728
75E	0.19908	0.085556
75F	0.06708	0.085556
75G	0.00300	0.209429
75P	0.00200	0.209429
75Y	0.00000	0.296177
76B	0.00000	0.296177
76C	0.86804	0.087904
76D	-0.02700	0.171113
76E	-0.04750	0.209640
76G	-0.05667	0.171456
76J	0.11550	0.085556
76L	-0.09550	0.210270
76M	0.00400	0.296177
76N	0.01000	0.296177
76P	0.39881	0.086964
76R	0.00400	0.296177
76T	0.00000	0.296177
76U	-0.04750	0.209640
76V	0.45208	0.087614
76W	0.50340	0.087815
76X	0.00695	0.086921
76Y	1.87441	0.087540
77F	0.00550	0.120954
77W	0.01400	0.296177
78E	0.00500	0.296177
81B	0.06950	0.085499
81C	0.05636	0.089301
81E	0.09417	0.085513
81Q	0.04600	0.089301
82B	-0.00238	0.089708
82C	0.31163	0.087541
82D	0.00982	0.089562
82E	0.00400	0.296177
83B	-0.09600	0.296773
83C	-0.09600	0.296773

MOS	Coefficient	Standard Error
83E	0.01945	0.089301
83F	0.05250	0.085499
84B	0.04164	0.089317
84C	0.00850	0.104714
84F	0.05517	0.085499
85B	-0.09550	0.210270
86B	0.00400	0.296177
88M	0.00825	0.148089
88N	0.00000	0.296177
91A	2.01383	0.087217
91B	1.73563	0.090098
91C	0.08977	0.089301
91D	0.20983	0.085556
91E	0.17150	0.086412
91F	0.10417	0.085499
91G	0.15425	0.085556
91H	0.03950	0.093659
91J	0.05300	0.089301
91K	-0.03033	0.171113
91L	0.00809	0.089317
91M	0.00500	0.296177
91N	0.02182	0.089317
91P	0.15600	0.085499
91Q	0.17792	0.085556
91R	0.14858	0.085556
91S	0.13558	0.085513
91T	0.12975	0.085556
91U	0.03208	0.085499
91V	0.00663	0.104714
91W	0.00500	0.296177
91Y	0.06042	0.085499
92A	0.00500	0.296177
92B	0.42833	0.085513
92C	0.02408	0.085513
92D	0.04655	0.089301
92E	0.00500	0.296177
92T	0.00000	0.296177
93B	-0.09550	0.210270
93C	-0.09550	0.210270
93D	0.04300	0.170998
93E	0.04350	0.209429
93F	0.03942	0.085513
93H	0.07795	0.085856
93J	0.07115	0.085728
93N	0.00400	0.296177
93P	0.16950	0.120914
94B	1.95388	0.088650
94D	0.00500	0.296177
94F	0.12675	0.085556
95B	6.12016	0.087540
95C	0.10636	0.089366

MOS	Coefficient	Standard Error
19A	0.88678	0.100995
36L	0.10425	0.085513
36M	0.23672	0.086411
36R	0.00000	0.296177
36T	0.00000	0.296177
19B	0.00133	0.170998
95D	-0.04500	0.209640
95L	0.00250	0.209429
95N	-0.09600	0.296773
95S	0.00500	0.296177
96B	0.32142	0.085628
96C	0.04023	0.095294
96D	0.08825	0.085513
96F	0.04133	0.170998
96H	0.03092	0.085499
96R	0.05020	0.132454
97B	0.00833	0.121561
97E	-0.01582	0.133788
97G	-0.02445	0.209639
98C	-0.05144	0.090490
98E	-0.09600	0.296773
98G	-0.18629	0.098153
98H	0.00400	0.296177
98J	0.08486	0.086428
11X	4.21633	0.324210

Manpower and Personnel Policy Research Group

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LOSSES FROM THE DELAYED ENTRY PROGRAM:
A TIME SERIES APPROACH

ABRAHAM NELSON
U.S. ARMY
Research Institute

DONALD PATCHELL
U.S. ARMY
Recruiting Command

Approved for Distribution to Sponsor or Proponent.

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Reviewed by: Edward J Schmitz

Approved by: Curtis L. Gilroy

Curtis L. Gilroy
Chief, Manpower and Personnel
Policy Research Group

Manpower and Personnel Research Laboratory

U. S. Army Research Institute
for the Behavioral and Social Sciences
5001 Eisenhower Avenue, Alexandria, VA 22333-5600

LOSSES FROM THE DELAYED ENTRY PROGRAM: A TIME SERIES APPROACH

I. INTRODUCTION

The Delayed Entry Program (DEP) is a very effective management tool for the Army, allowing an individual to sign an enlistment contract and delay his or her reporting for active duty for up to twelve months. An individual signing an enlistment contract who either goes on active duty immediately or within one month is called a "direct ship;" otherwise he or she enters the DEP. Individuals in the DEP who decide to abrogate their enlistment contracts are not forced to enter the Army. They are losses from the DEP.

There are several positive aspects of DEP. First, this program permits the Army to smooth out the training load. The time at which an individual is scheduled to enter the Army is determined by the time and availability of the appropriate training course open to him or her. Secondly, as Morey (1983) postulated, individuals in the DEP provide referrals from their peers and hence increase the production of recruiters. Finally, Manganaris and Schmitz (1985) found that those individuals who enter active duty after spending time in the DEP attrite at a lower rate than those who do not enter the DEP (ceteris paribus).

Although the DEP is a valuable tool for force management, there are some drawbacks to using it. First, time in the DEP is associated with lower probability of shipping (Phillips & Schmitz, 1985; Celeste, 1985; and Quester & Murray, 1986). A second issue is that recruiting resources are used, especially recruiter time, in managing DEP which could have been employed in other activities.

Although the benefits of DEP greatly outweigh its costs, its management, nevertheless, must be efficient and effective. An essential step in managing the DEP is understanding the causes of DEP loss. The purpose of this report is to investigate the environmental factors and management policies influencing DEP loss.

DEP losses adversely impact recruiting productivity. Recruiter effort and other recruiting resources are wasted when an individual becomes a DEP loss. To compensate for such losses additional enlistment contracts must be obtained. This requires the expenditure of additional resources, including recruiter time. Thus, productivity is diminished when a DEP loss occurs.

The Army's ability to smooth the flow of individuals into training slots during the year is also diminished as a result of DEP losses. Training slots may, in fact, go empty because of DEP losses. Training resources are thus wasted, and individuals are denied opportunities to fill training slots.

In FY86 the DEP loss rate was 8.1 percent for I-IIIA high school degree senior and graduate males (GSMAs) and this rate increased to 9.3 percent in FY87 (USAREC Commanders Conference, September, 1987). In absolute numbers this meant that an additional 1,098 GSMA individuals were lost from the DEP. (These numbers were calculated omitting August and September of both years because they were not available for FY87.) This represents a significant increase in DEP losses for this group.

This report attempts to identify the contribution of selected factors toward DEP loss. In Section II a description of the methodology employed is provided. Results and descriptive statistics are reported in Section III. Conclusions and directions for future research are reported in Section IV.

II. METHOD

Earlier work of Phillips et al. (1985) and Celeste (1985) found that the following individual characteristics differentiate DEP losses: gender, education, and Armed Forces Qualification Test (AFQT) scores. They also found that length of time in the DEP was related to DEP loss; as DEP length increases the probability of being a DEP loss increases.

Environmental factors such as labor market conditions may also influence DEP loss. Most models, however, do not take into account such economic factors. It is an accepted fact that youth unemployment significantly influences Army enlistments. Hence, it is not unreasonable to conjecture that it also influences individuals' decisions to fulfill their contract obligation.

In addition, it is not untenable to assume that the number of individuals in the DEP relative to the number of recruiters influences DEP loss. The number of individuals per recruiter affects the amount of time recruiters can spend managing each contract. The less time a recruiter has to manage individuals in the DEP the greater the probability they will become DEP losses.

The model estimated here uses monthly time-series data supplied by USAREC covering fiscal years (FY) 1984 through 1987, and takes the form:

$$\text{DEPLR} = \beta_0 + \beta_1 \text{*UNEM} + \beta_2 \text{*AVDEPL} + \beta_3 \text{*DEPREC} + \text{ERROR TERM}$$

where DEPLR is the DEP loss rate (number of DEP losses ÷ DEP losses + accessions). Independent variables include UNEM, the unemployment rate for 16- to 19-year olds; AVDEPL, the average DEP length (in months) for the period; and DEPREC, the number of individuals in the DEP per recruiter. The mean values and the standard deviations of these variables are reported in the appendix,

Table A1. An ordinary least squares (OLS) technique is used to estimate the model. This specification assumes that the random disturbances are uncorrelated. If the disturbances are correlated for a linear regression model involving time series data, then autocorrelation is said to be present. The Durbin-Watson test for autocorrelation is employed here and, at 1.45, does not strongly indicate that the assumption of uncorrelated disturbances is violated.

III. RESULTS

The estimated coefficients and t-statistics are presented in Table 1. All variable coefficients are significant at the .01 level, and all have the expected signs. For example, the parameter estimate for UNEM measures the effect of changes in the youth unemployment rate on the DEP loss rate; an absolute increase of 1 percent in youth unemployment is associated with an absolute decrease of .67 in the loss rate. Similarly, an increase of one month in average months in DEP (AVDEP) increases the DEP loss rate by over 0.5 percent, while an increase of one in the ratio of the size of the DEP to the number of recruiters (DEPREC), which is the result of either reducing the number of recruiters or expanding the size of the DEP pool, increases the DEP loss rate by over 1.9 percent. R^2 and the mean square error (MSE) for the model are also reported. These statistics indicate that the variables explained 70% of the change in DEP loss over the FY84-87 period, and estimated DEP loss with average mean squared error of about 1.4 percent.

The results from the model are used to examine the impact of each factor on the change in the GSMA DEP loss rate between FY86 and FY87. The actual differences for all variables for FY86 versus FY87 are examined in Table 2. They indicate that: (1) the labor market became more competitive--

Table 1: ORDINARY LEAST SQUARES REGRESSION RESULTS FOR DEP LOSS MODEL (1984-87)
(Dependent Variable: DEP Loss Rate)

VARIABLE	PARAMETER ESTIMATE	t - STATISTIC
UNEM	-.670	-3.594
AVDEP	.542	4.508
DEPREC	1.931	4.483
CONSTANT	8.950	2.038
$R^2 = .70$		
MSE = 1.37		

unemployment dropped about one and one half percentage points; (2) the demand on recruiter time increased; and (3) the amount of time available for a recruit to attrite from the DEP increased. With these changes, an increase in the DEP loss rate should have been anticipated and, in fact, was realized.

Table 2: DIFFERENCES BETWEEN FY86 AND FY87 VARIABLES

	DEP LOSS RATE	UNEMPLOYMENT RATE	DEP per RECRUITER	AVERAGE DEP LENGTH
FY86	7.18	19.52	4.775	4.267
FY87	9.88	18.09	5.025	4.765
DIFFERENCE	2.70	-1.43	.25	.49
PERCENT DIFFERENCE	37	-7	5	16

The observed and predicted DEP loss rate changes between FY86 and FY87 and the contributions of each factor to these changes are presented in Table 3. The changes for the observed and predicted rates are 2.70 and 1.71,

respectively. This disparity represents a 37 percent underprediction of the DEP loss rate by the equation. This underprediction may reflect a one-time policy change that took effect in January 1987. It was at this point that nongraduates from the previous summer who failed to obtain their diploma were purged from the DEP. This may be the reason the model underpredicts the losses for January 1987 (See the appendix).

Table 3: FACTOR CONTRIBUTION TO FY86-FY87 DEP LOSS RATE CHANGE

		FACTOR CONTRIBUTION			
	DEP LOSS RATE CHANGE	UNEMPLOYMENT RATE	DEP PER RECRUITER	AVERAGE DEP LENGTH	ERROR
OBSERVED LOSS RATE	2.70	39%	18%	10%	33%
PREDICTED LOSS RATE	1.71	56%	28%	16%	0%

All factors considered in the model contribute to the increases in the DEP loss rates. The unemployment rate of 16 to 19 year olds influences the changes in the observed and predicted DEP loss rates more than any other factor, however. In fact, nearly 40% of the increase in the actual loss rate and 56% of the increase in the predicted loss rate are attributable to declining unemployment alone. The other factors contribute to the increases in both loss rates to a lesser extent. (See Table 3).

The actual and predicted DEP loss rates and the errors in the prediction, the residual, for each month from FY86 through FY87 are reported in the appendix, Table A2.

IV. CONCLUSIONS AND DIRECTIONS FOR FURTHER RESEARCH

Overall the model specified in this effort is appropriate. An $R^2 = .70$ indicates that the equation fits the data. All factors -- unemployment, DEP

per recruiter, and average DEP length — significantly affect DEP loss.

Although the equation estimated here underpredicts the change in the DEP loss rate from FY86 to FY87, it does account for a substantial proportion of the actual loss rate. Moreover, the estimated equation indicates that nearly 40% of the increase in the loss rate was due to one factor, the decline in the 16- to 19-year old unemployment rate.

Irrespective of how well the equation fits, improvements are nevertheless possible. The inclusion of other factors such as geographic variation, for example, or the effects of specific policies such as enlistment bonuses, the Army College Fund, and occupation choice on DEP loss may prove to be valuable in the estimating equation. To investigate these effects, an individual level microdata model is necessary; this will be the direction for the follow-on effort.

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APPENDIX

Table A1: MEAN VALUES OF RECRUITING AND DEP LOSS FACTORS

VARIABLE	MEAN	STANDARD DEVIATION
DEP Loss Rate	7.38	2.42
Unemployment Rate (16-19)	19.23	1.14
Size of DEP per Recruiter	4.65	0.51
Average DEP length	4.34	1.86

TABLE A2: ACTUAL AND PREDICTED LOSS RATES AND RESIDUALS

MONTH-YEAR	ACTUAL LOSS RATE	PREDICTED LOSS RATE	RESIDUAL
OCT83	6.2872	5.8782	0.4090
NOV83	5.5529	7.0326	-1.4797
DEC83	5.7807	6.4219	-0.6412
JAN84	5.6860	6.5284	-0.8424
FEB84	5.8803	6.8867	-1.0064
MAR84	5.6052	5.8429	-0.2377
APR84	5.7333	5.2840	0.4492
MAY84	6.5712	6.2864	0.2847
JUN84	9.0429	9.0030	0.0399
JUL84	7.3660	8.2664	-0.9004
AUG84	6.3319	8.4668	-2.1349
SEP84	6.9698	7.0363	-0.0665
OCT84	4.3947	4.5424	-0.1477
NOV84	5.2685	5.2664	0.0021
DEC84	5.5616	4.3057	1.2559
JAN85	5.6670	4.9531	0.7139
FEB85	4.9131	4.7719	0.1411
MAR85	4.9755	5.4542	-0.4788
APR85	4.5317	5.9694	-1.4377
MAY85	6.5312	6.4628	0.0684
JUN85	8.7803	9.3654	-0.5852
JUL85	7.9060	8.4135	-0.5076
AUG85	7.3359	7.6128	-0.2769
SEP85	7.0113	6.5762	0.4351
OCT85	5.7929	4.1691	1.6238
NOV85	5.1320	5.5559	-0.4239
DEC85	6.6935	6.0177	0.6758
JAN86	6.9791	7.7247	-0.7455
FEB86	5.2598	6.6316	-1.3717
MAR86	5.0559	6.5758	-1.5198
APR86	5.5278	6.3306	-0.8028
MAY86	7.3681	7.0371	0.3310
JUN86	11.7392	10.1796	1.5596
JUL86	10.0357	11.1187	-1.0829
AUG86	7.9978	9.1559	-1.1581
SEP86	8.5684	8.3883	0.1802
OCT86	6.1484	8.2288	-2.0805
NOV86	6.4258	7.5830	-1.1572
DEC86	8.1664	7.4681	0.6983
JAN87	13.3243	8.2154	5.1089
FEB87	6.9219	7.7903	-0.8684
MAR87	7.5709	7.4074	0.1635
APR87	11.0681	7.8023	3.2659
MAY87	9.1442	7.8410	1.3032
JUN87	13.6669	12.3304	1.3366
JUL87	12.4404	13.5289	-1.0886
AUG87	10.9442	10.8559	0.0884
SEP87	12.6726	10.3239	2.3486

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SERVICE-SPECIFIC PROPENSITY TO ENLIST

AMONG HIGH AFQT MALES

Roy Nord

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REVIEWED BY: Edward J. Schmitz

APPROVED BY: Curtis L. Gilroy

U.S. Army Research Institute
for the Behavioral and Social Sciences
5001 Eisenhower Avenue, Alexandria VA 22333

SERVICE-SPECIFIC PROPENSITY TO ENLIST AMONG HIGH AFQT MALES

Information about the stated intentions of young men and women with respect to military service, commonly referred to as "propensity to enlist", has been shown to be useful in predicting subsequent enlistment behavior in a number of studies (see, e.g., Orvis and Gahart 1985, and Nord, Schmitz and Weiland, 1986). In addition, it has been shown that (a) the probability of being positively inclined toward enlistment in any service varies inversely with measures of recruit quality such as possession of a high school diploma and Armed Forces Qualification Test (AFQT) scores; and (b) the ratio among service-specific propensities varies across quality groups.

The most widely used source of propensity information is the Youth Attitude Tracking Survey (YATS), a telephone survey administered annually to a random sample of 16-21 year-olds. Respondents are asked to indicate their intentions toward military service on a four-point scale ranging from "definitely intend to enlist" to "definitely intend to not enlist". In general, respondents indicating that they "definitely" or "probably" intend to enlist are identified as having a "positive propensity" to enlist. (The YATS also contains an open-ended question asking what the respondent expects to be doing one year after the interview. At least one study (Orvis, 1985) examines the frequency of "unaided mention" of military service in response to this question.) Respondents who indicate a positive propensity are asked for additional information on the specific service they prefer. The Defense Manpower Data Center provides annual summaries of these results, broken down by service and a variety of demographic categories.

Unfortunately, the YATS does not provide any direct information on AFQT performance, and as a result, the most widely available propensity information has not taken into account the differences in propensities across AFQT categories. This limitation, combined with the fact that recruiting resource allocation decisions both within and across services are largely driven by the difficulty of attracting high-school graduates with above average AFQT scores, has severely constrained the usefulness of propensity information to military policy-makers.

Recent research has addressed this problem from two directions -- first by developing a procedure to impute AFQT categories for YATS respondents (Orvis 1985); and second, by analyzing the propensity information provided by the National Longitudinal Survey of Labor Market Participation, Youth Survey (NLS). The Orvis results show that trends in service-specific propensities among "high quality" males (those with high school diplomas in AFQT categories I-IIIA) are markedly different from trends among all males. The most recent YATS results for the 16-21 high-school diploma graduate (HSDG) male population indicate that propensities for the Army and Air Force are nearly equal, with Navy propensities substantially lower, exceeding Marine propensities by only a small margin. Orvis' analysis of the same data indicates that, among category I-IIIA HSDG males, the propensity toward Air Force enlistment substantially exceeds that of all other services, and that the relative positions of the Army and Navy are reversed, with propensity toward Navy enlistment exceeding that for the Army by a small margin.

The analysis reported here uses data from the NLS to estimate service-specific propensities among MCAT I-IIIA HSDG males. These estimates of "net" propensities are compared to the "raw" propensities for all HSDG NPS males to determine whether patterns similar to those reported by Orvis emerge. In particular we are interested in whether or not there are significant shifts in the relative positions of the services when net rather than raw propensities are used.

The NLS sample was restricted to youths aged 14-21 in 1979, and this population was re-interviewed annually to produce a longitudinal data base. As a result, the most recent year for which a 16-21 year-old sample can be obtained from the NLS is 1981. We chose to extend this limit to 1982 by focusing on 17-21 year-olds to obtain the most current results possible without excluding large numbers of the prime target population.

(One caveat with respect to the categorization of NLS respondents by AFQT scores should be noted: AFQT scores on the NLS were obtained by an administration of the test to respondents in 1980. This means that the 17 year-olds in the 1982 sample were 15 years old when the test was administered, and their scores are likely to be biased downward).

The data displayed in Table 1 reveals the following:

o As expected, propensities are much lower among youths in the upper half of the AFQT distribution ("net" propensity) than among the youth population at large ("raw" propensity).

o Changes from year to year in propensity toward military service in **any** branch among the general youth population are generally similar in **direction** to the high-AFQT population. These changes are proportionally smaller in the general youth population -- i.e., raw propensity estimates are relatively more stable over time than are net estimates. (This is undoubtedly partially due, to the small sample sizes used to estimate "net" propensity).

o The estimates of service-specific propensities reveal notable differences between net and raw propensities with respect to both year-to-year changes and cross-service comparisons. Between 1981 and 1982, for instance, raw Army propensity rose roughly 9%, while net propensity showed a 20% decline. Comparing Army, Navy, and Air Force raw propensities in 1982 suggests that Air Force propensity is 50% higher than that of the Army, and more than 100% higher than that of the Navy. Similar comparisons among net propensities indicate that, for high-AFQT youth, Air Force propensity is nearly 200% higher than Army and 250% higher than Navy propensity.

In light of the fact that recruiting policies are aimed at I-IIIA HSDG male accessions, these findings suggest, as do those of Orvis, that raw propensity estimates provide an unreliable basis for resource allocation decisions either within or across services. It would appear to be well worthwhile to seek the improvements in data collection instruments and analytical techniques needed to provide reliable, quality-specific propensity estimates in the future.

TABLE 1
"RAW" VS "NET" PROPENSITY TO ENLIST BY SERVICE
17-21 YEAR-OLD NPS HSDG MALE POPULATION
1979-1982 NLS DATA

A. ALL 17-21 YEAR-OLD NPS HSDG MALES ("RAW" PROPENSITY)

	1979	1980	1981	1982
MILITARY	14.5	17.6	15.5	14.7
(N)	(427)	(503)	(471)	(383)
ARMY	2.9	3.9	3.2	3.5
(N)	(104)	(131)	(110)	(113)
NAVY	3.4	3.7	2.6	2.5
(N)	(83)	(99)	(78)	(64)
AIRFORCE	5.1	6.2	5.0	5.3
(N)	(154)	(178)	(148)	(127)
MARINES	1.6	1.9	2.4	1.4
(N)	(47)	(54)	(66)	(37)
TOTAL OBS	2446	2445	2430	2105

B. MCAT I-IIIA ONLY ("NET PROPENSITY")

	1979	1980	1981	1982
MILITARY	9.7	12.2	9.6	7.5
(N)	(119)	(137)	(106)	(67)
ARMY	1.5	2.4	1.5	1.2
(N)	(20)	(32)	(21)	(13)
NAVY	2.2	2.6	2.3	1.0
(N)	(26)	(27)	(23)	(11)
AIRFORCE	4.0	4.6	3.5	3.5
(50)	(53)	(35)	(27)	
MARINES	0.7	0.9	1.2	0.7
(N)	(10)	(11)	(13)	(6)
TOTAL OBS	1041	1000	943	780

NOTES

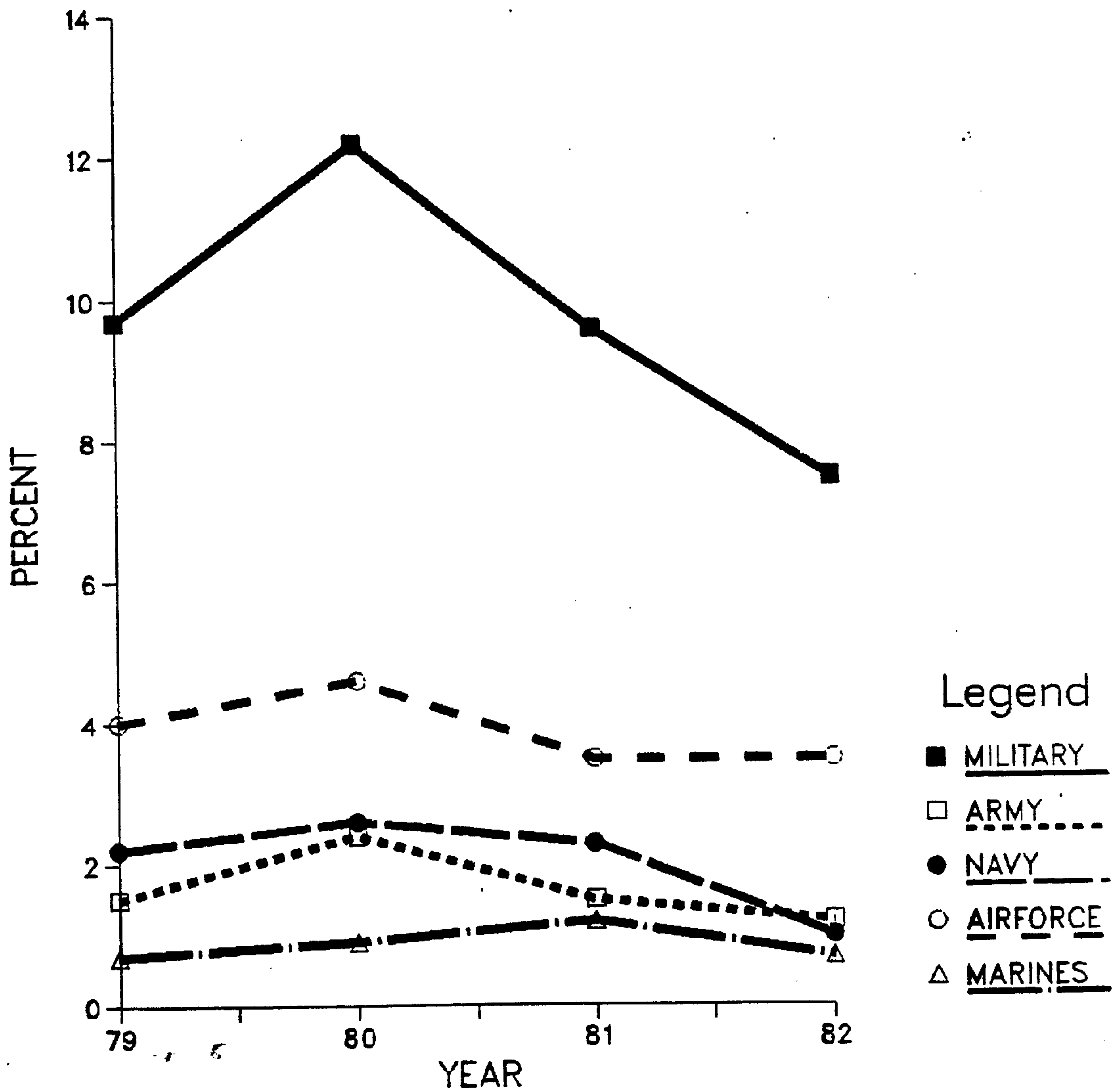
(a) **MILITARY** includes respondents indicating a propensity for National Guard and Reserves as well as the major branches.

(b) "N" is the number of respondents indicating a positive propensity for each (or any) service.

(c) **TOTAL OBS** is the total number of respondents on which the percentages are calculated, i.e., the number of 17-21 NPS HSDG males in the sample for Table 1a, and the number of I-IIIA within this group in Table 1b.

(d) Percentages were calculated using the NLS sample weights for each year. For this reason, percents are not equal to 100*(N/TOTAL OBS).

PERCENT OF 17–21 YEAR–OLD MCAT I–IIIA HSDG MALE POPULATION
WITH POSITIVE PROPENSITY TO ENLIST
1979–1982 NLS DATA



NOTE: MILITARY includes National Guard and Reserves.

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A DURATION TIME MODEL OF ENLISTED PROMOTION

Roy Nord

June 1987

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U.S. Army Research Institute
for the Behavioral and Social Sciences
5001 Eisenhower Avenue, Alexandria VA 22333

PB 8805

A DURATION TIME MODEL OF ENLISTED PROMOTION

Roy Nord, U.S. Army Research Institute

In this paper a model of the relationship between a selected characteristics of Army recruits and their relative speed of promotion to the ranks of sergeant and staff sergeant is estimated. The focus is on the links between promotion to these levels and two widely used measures of recruit "quality" -- Armed Forces Qualification Test (AFQT) scores and educational attainment (high school graduation).

It is argued that relative speed of promotion is a reasonable indicator of overall soldier performance and as such, provides a good criterion for assessing the validity of AFQT scores and educational attainment as predictors of job performance among first and second term soldiers. Results achieved using a statistical model of the process reveals that both AFQT scores and educational attainment are reliable indicators of soldier performance as measured by relative promotion speed.

MEASURING SOLDIER PERFORMANCE

Soldier performance is of primary interest in a wide variety of military policy problems. These include the development of effective recruitment, selection, classification, assignment, and training policies and programs the efficient allocation of resources among these activities. To a large extent, the usefulness of a given performance measure -- indeed the definition of what "performance" is -- depends on the policy problem to which it will be applied. Under current data limitations it is not possible to identify a single measure which is equally valid for all applications. One of the most widely used measure of soldier performance is the Skill Qualification Test (SQT). Horne (1986), for example, examined the links between high school graduation status, AFQT scores, and SQT scores of first-term Army enlisted soldiers. These results show a strong positive relationship between AFQT and SQT scores, and a weaker, but significant positive link between SQT and possession of a high school diploma. These results are consistent across several model specifications.

Armor, et. al. (1982) and Fernandez and Garfinkle (1985) combined SQT scores with expected length of service to obtain a measure of "qualified man-years". The focus in these two studies was on the identification of optimal job-specific minimum entry standards. Both studies revealed strong positive effects of these predictors on expected qualified man-years in the Military Occupational Specialties (MOS) analyzed. A number of previous studies have shown that high school completion is a strong predictor of whether or not a recruit completes his first enlistment (see, e.g. Manganaris and Schmitz, 1985).

The advantages of using SQT scores as performance measures are that they are widely available, relatively easy to obtain, and familiar to both soldiers and Army decision-makers. The most important weakness of SQTs as performance measures is the fact that they are designed to measure job knowledge rather than job performance. While it is reasonable to expect that such knowledge is a necessary condition for satisfactory performance, the ability to demonstrate familiarity with approved techniques and procedures in the context of a written test does not imply superior performance on the job. This limitation is particularly worrisome if the purpose of the performance measure is to test the usefulness of another written test as a predictor of performance.

In addition, SQTs focus on a limited subset of the tasks required in any given job. The relevance of these tasks to overall performance as well as the degree of difficulty of the tasks varies considerably across jobs. This makes comparison across jobs difficult. Furthermore, the SQT is used for evaluative as well as diagnostic purposes. In its review of the SQT, the General Accounting Office (1982) found that this fact tended to produce disproportionate training on the subset of tasks covered by the test. To the extent that such "coaching" occurs, the usefulness of SQTs as overall measures of performance will be further reduced.

A second group of soldier performance analyses have relied upon observations of soldiers actually using specific weapons systems. Scribner, et. al. (1986) analyzed the effects of tank crew AFQT scores, educational attainment and experience levels on the performance of the tank in gunnery exercises. Nelson et al. (1984) examined the effects of AFQT differences among soldiers selected against test performance for the STINGER missile. Horne (1986) conducted a similar analysis using system-specific training data on the Hawk, STINGER and other air defense systems collected by the Systems Analysis Activity of the Army's Training and Doctrine Command. Again, all of these studies revealed a significant positive effect of recruit quality measures on the selected measure of soldier performance.

The weapons trial results provide performance indicators that are in many respects the most persuasive available because of their direct links to concrete and critically important tasks. However, these measures are not available for most Army jobs. Even where they are available, they measure only some of the determinants of overall soldier performance, and the collection and summarization of data on the results of the exercises further narrows this focus. As a result, these analyses may underemphasize important, but difficult-to-measure qualities like decision-making skills and leadership abilities.

Promotion as a Performance Measure

The use of promotion as an indicator of performance is not new, although its use in analyses of public sector activities has been somewhat limited. Ward and Tan (1985) used a combined measure of promotion speed and length of service to examine the Army's re-enlistment standards.

Promotion speed is a logical choice as a indicator of soldier performance for a number of reasons. The Army's "up or out" policy, under which failure to be promoted may bar a soldier from re-enlistment, provides implicit evidence that promotion is perceived by the Army, as evidence of competence. The regulations governing promotion, explicitly state that the promotion system is intended to reward merit. This intent is further embedded in the detailed procedures by which promotion "points" are determined.

It should be noted, however, that the system, also rewards tenacity. Minimum requirements for time-in-grade and time-in-service are established by grade. In addition, until June, 1985, time-in-service was used, along with performance data, in the calculation of promotion points. (These requirements can be partially waived in cases of exceptional performance.)

The data on which promotion decisions are based includes commander judgements of individual capabilities and potential, as well as performance on SQT tests, education, training and other "objective" measures of job proficiency. If one is willing to accept the argument that (a) promotion policies tend to reflect the values of the Army; (b) the implementation of these policies (i.e. the actual decisions of individuals and organizational sub-units) are, at least on average, consistent with their intent; and (c) job performance should be judged in terms of the organization's values, then speed of promotion, should reflect soldier contributions to military effectiveness in the broadest sense.

Much of the literature on promotion has focused on the elements of this argument. Frequently, the promotion-performance link is treated normatively. The null hypothesis is that promotion is based on job performance, and the analytic objective is to test this hypothesis by examining whether variables posited to be unrelated to performance are in fact determinants of promotion. Rejection of the null hypothesis is interpreted as evidence either (a) that organizational objectives are not reflected in promotion policy, or (b) that the individuals making promotion decisions fail to follow the policy.

Our approach reverses these assumptions. Our primary interest is in testing the hypothesis that our recruit "quality" indicators are unrelated to performance. We shall do so by assuming that promotion is based on performance, and testing the ability of AFQT and education to predict promotion speed.

Data were examined for eight different MOS widely distributed with respect to the kind and quality of skills required. Promotions to E-5 (Sergeant)and E-6 (Staff Sergeant)in each MOS were analyzed. The initial sample consisted of all individuals in grades E-2 through E-6 at any time between September, 1980 through September, 1984. The duration analysis required at least two successive observations on each individual, and

observations failing to meet this requirement were dropped, as were cases with missing or invalid data. The resulting samples ranged from 880 to 33,900 records, each representing between two and five observations on an individual.

The sample was drawn from the records contained in the year-end Enlisted Master File compiled in September of each year by the Military Personnel Center. (Corrected AFQT scores for individuals entering the service during the 1976-1980 "misnormed" period were obtained from the Cohort Files produced by the Defense Manpower Data Center.)

MEAN TIME TO PROMOTION

One way to examine the effects of AFQT and education on promotion speed is to classify the observations by these variables, and examine differences in average time taken to be promoted to each grade. Butler (1976) used this approach to examine aggregate Army promotion data for evidence of racial discrimination as well as to explore the effects of test scores and education on promotion problems.

One problem created by analysis of promotions for a single time period is that the dynamic aspects of the promotion system must be ignored. The probability of being promoted during any given interval is dependent on the availability of positions in the destination grade and the number of people eligible to fill those positions. Since both of these factors vary with time, the composition of a particular grade in a given MOS at any point in time is dependent on the accession composition of the cohorts in preceding periods.

A second and more serious flaw in the use of mean promotion times is failure to account for the potential biases introduced by censoring. The probability that a given individual will be observed in a given grade at a given time is conditional on (a) the probability of remaining in the service long enough to attain that grade; and (b) the length of time the individual remains in grade before being promoted or leaving the service. To the extent that the determinants of length of service are correlated with unobserved determinants of promotion speed, a model that ignores the conditional nature of the distribution of individuals in a given grade will produce biased results.

Simple comparisons of mean promotion times within the population of a given grade ignores selection effects that have major impacts on the composition of that population. The marked difference in the results of the two models suggest that these effects operate differently among blacks, whites, males and females. The selection factors that increase the likelihood of exiting the Army with less than two terms of service will tend to cause "front" (left) censoring of the observed data because (for the grades we are analyzing) promotion does not usually occur until the second term. Those factors that tend to increase transit speed

through a given grade (this includes both rapid promotion and exit from the service) will tend to cause "rear" (right) censoring of the data.

To deal with these issues, a "duration" approach was chosen that allows for correction of front and rear censoring as well as for cohort effects. These models have been widely applied in engineering to investigate the performance of machines and complex systems. They have also been used to examine first-term retention (Baldwin and Daula 1984). A brief description of the approach is provided here. A more detailed exposition can be found in Amemiya (1985).

The objective of the duration approach is to find consistent estimates of the determinants of the instantaneous probability of promotion at a specific time. Let the probability that an individual with characteristics Z is promoted prior to time t be represented by

$$F(t|Z;\beta)=\mathrm{Prob}(T\leq t|Z) \tag{1}$$

where β is a column vector of coefficients on the elements of the row vector Z, T is the time in grade when promotion occurs, and t is a random variable ranging from 0 to infinity. Then the istantaneous rate of promotionat time T is given by

$$f(t|Z;\beta)=\lim_{\Delta\to 0} \mathrm{Prob}(t\leq T\leq t+\Delta)=dF(t)/dt \tag{2}$$

The instananeous rate of promotion relative to the population remaining in the relevant grade at time t -- the "hazard rate" (h) -- is simply the conditional density, formed by dividing the density function f by the probability of surviving to time t

$$\lim_{\Delta\to 0} \mathrm{Prob}(t\leq T\leq t+\Delta|T\geq t,Z;\beta) \equiv h(t)=f(t|Z;\beta)/1-F(t|Z;\beta). \tag{3}$$

In order to carry out the estimation, it is necessary to specify a distribution for the random variable t. We have used the Weibul distribution because it allows the failure rate to increase, remain constant or decrease.

This yields

$$f(t)=act^{c-1}\exp(-at^{c});\ (c>0,\ a>0) \tag{4}$$

where a is the "scale" parameter and c the "shape" parameter of the Weibul distribution. This specification produces the hazard function

$$h(t)=act^{c-1} \tag{5}$$

The explanatory variables z are incorporated into the model by specifing the shape parameter as

$$a=\exp(Z\beta) \tag{6}$$

Note that the hazard rate will increase in t for values of c greater than 1, decrease for c<1 and remain constant for c=1. This specification does imply, however, that the hazard rates of individuals with different characteristics are in constant proportion over the entire range of the variable t, hence the name "proportional hazards model" that is often applied to this specification. This limitation on flexibility can be overcome by estimating separate models for periods that may be expected to violate the proportionality assumption. However, because there is no *a priori* reason to believe that this proportionability assumption is violated in this application, we have not investigated this refinement.

Given these assumptions, the contribution of the i^{th} observation to the log likelihood function is given by:

$$L_i = I_1 \{\exp(\mathbf{x}\beta)ct_1^{c-1}\exp[-t_1^c \exp(\mathbf{x}\beta)] \tag{7a}$$

$$+ I_2 \{(\exp(\mathbf{x}\beta)ct_1^{c-1}\exp(-t_1^c \exp(\mathbf{x}\beta)])/\exp[-t_0^c \exp(\mathbf{x}\beta)]\} \tag{7b}$$

$$+ I_3 \{\exp[-t_1^c \exp(\mathbf{x}\beta)]\} \tag{7c}$$

$$+ I_4 \{(\exp[-t_1^c \exp(\mathbf{x}\beta)])/\exp[-t_0^c \exp(\mathbf{x}\beta)]\} \tag{7d}$$

where

I_1 = 1 if individual i was promoted and was observed when entering the source grade (i.e., was not front-censored), 0 otherwise;

I_2 = 1 if individual i was promoted but was not observed entering the source grade (i.e., was front-censored), 0 otherwise;

I_3 = 1 if individual i was not promoted and was not front-censored, 0 otherwise;

I_4 = 1 if individual i was not promoted and was front-censored, 0 otherwise;

c = the Weibul shape parameter;

$\mathbf{x}$ = a row vector of values for individual i of the explanatory variables;

β = the column vector of coefficients on those variables;

t_1 = time (months) in grade when individual i was promoted from source to destination grade or censored; and

t_0 = time (months) in source grade when individual i was first observed (0 if not front-censored); and

The different forms for the contribution to the likelihood function have the following interpretation:

(7a) is the unconditional instantaneous probability of being promoted;

(7b) is the probability of being promoted given that entry to the source grade had occurred prior to the first observation on the individual;

(7c) is the unconditional probability of <u>not</u> being promoted during the interval over which the individual was observed; and

(7d) is the probability of <u>not</u> being promoted during the interval of observation, <u>given</u> that entry to the source grade had occured prior to the beginning of that interval.

The explanatory variables included in the model can be divided into four groups: (a) variables hypothesized to affect performance directly (AFQT score, educational attainment, and previous experience (as represented by time in service at promotion to the source grade); (b) variables required to measure variations over time in advancement opportunities (Cohort dummy variables); (c) demographic characteristics that may affect performance and service tenure indirectly or reflect the effects of systematic biases in the promotion system (Marital status, number of dependents, race and sex).

RESULTS

Coefficient estimates are presented in Tables 1 and 2. In interpreting these numbers, it should be noted that because of the formulation of the model, the coefficients are inversely related to time to promotion. Variables with positive coefficients tend to reduce time to promotion.

AFQT scores are good predictors of soldier performance, as measured by time in grade at promotion. The effect is positive and significant for all MOS and both grade levels analyzed. Furthermore, the effects are roughly similar in magnitude to those found in earlier studies using different performance measures. This consistency is reassuring in that it simultaneously adds credence both to the results obtained in earlier studies and to the basic assumptions underlying the promotion-time model.

The effect of AFQT was generally larger than that of education, in spite of the fact that education is explicitly considered in the promotion decision, and AFQT score is not. Indeed, the effect of AFQT was larger

than any other variable except "experience" (time in service at promotion to the source grade).

The large and consistent impact of time in service reflects the fact that, this variable entered the promotion decision at two points -through minimum TIS requirements for eligibility and in the calculation of promotion points. A correction for this effect was attempted by calculating t_0 and t_1 from the minimum time-in-service and time-in-grade requirements. Nevertheless, results indicated that individuals who received rapid promotion through the lower grades were "held up" by seniority requirements. One would expect this to reduce the size of the effects of AFQT and education. The effect of race is generally insignificant, and in those cases where it is significant, it is as likely to be positive as negative. The coefficients on gender are remarkably strong and consistent, revealing that women tend to be promoted more slowly than men in all jobs and in both grades examined. It is interesting to note that this effect is smallest for both E5 and E6 promotions in the MOS (63B, Wheel Vehicle Mechanics)that is perhaps the least traditional for women. In fact the effect of gender on promotion to E6 in this MOS is insignificant.

In order to more directly evaluate the magnitude of the effect of test scores on promotion times, the coefficients were used to generate times to promotion for different education levels and AFQT scores. These projections are presented in Tables 3 and 4.

In general, the promotion times are longer than those actually observed because the model provides estimates of what would occur if everyone remained in the service long enough to be promoted. While this may appear unrealistic, it is neccessary to allow generalization of the findings beyond the particular policy context in which the model was estimated. This does mean that the projections should be interpreted relative to each other, rather than as predictions of actual promotion rates.

The projections reveal clearly the substantial effect of AFQT on time to promotion. A high school graduate with an AFQT score of 60 will be promoted to E-5 between 2 and 9 months faster than a similar soldier with and AFQT of 40, and to E-6 from 2 to 18 months sooner. These differences translate into proportional effects of between 8 and 19 percent for E-5 promotions and 6 to 14 percent for promotions to E-6.

The effects of both AFQT and education tend to be smaller for combat than for non-combat MOS. This finding may reflect the greater importance in non-combat jobs of the cognitive skills measured by AFQT scores. However, such an interpretation should be made with caution. This result may also reflect higher rates of migration and exit from combat MOS, a phenomenon that would tend to increase opportunities for advancement and reduce the selectivity of the promotion process, with the net result being a reduction of the effect of performance as opposed to simple longevity as a determinant of promotion.

TABLE 1

DURATION MODEL COEFFICIENTS FOR E4 to E5 PROMOTIONS

BASE MODEL

	11B	19E	31V	51B	54E	63B	71L	76Y
INT	-7.6517* (0.1015)	-7.4008* (0.1542)	-8.3743* (0.4750)	-11.8576* (0.9353)	-6.8836* (0.2984)	-11.5796* (0.2038)	-11.0765* (0.2147)	-8.9617* (0.1932)
EDUC	0.0729* (0.0083)	0.0638* (0.0125)	0.0487 (0.0373)	0.2580* (0.0735)	0.0717* (0.0231)	0.2342* (0.0159)	0.2502* (0.0137)	0.1076* (0.0151)
AFQT	0.0089* (0.0003)	0.0075* (0.0005)	0.0044* (0.0014)	0.0115* (0.0019)	0.0029* (0.0011)	0.0083* (0.0006)	0.0111* (0.0007)	0.0041* (0.0007)
MSTAT	-0.1611* (0.0195)	-0.2403* (0.0332)	-0.3011* (0.0878)	-0.1330 (0.1180)	0.0178 (0.0556)	-0.0377 (0.0346)	-0.0757* (0.0382)	-0.0428 (0.0377)
RACE	-0.0767* (0.0181)	0.0252 (0.0269)	0.0006 (0.0699)	-0.0953 (0.0994)	-0.0067 (0.0506)	0.1309* (0.0293)	-0.0841* (0.0344)	0.0048 (0.0308)
NDEP	-0.0249* (0.0075)	0.0186 (0.0135)	0.0045 (0.0408)	-0.0276 (0.0545)	0.0366* (0.0182)	-0.0236 (0.0135)	-0.0883* (0.0147)	-0.0478* (0.0154)
TIS	0.0150* (0.0002)	0.0200* (0.0004)	0.0171* (0.0017)	0.0072* (0.0025)	0.0130* (0.0013)	0.0259* (0.0006)	0.0223* (0.0005)	0.0180* (0.0006)
SEX	**** ****	**** ****	-0.4202 (0.2706)	**** ****	-0.1167 (0.0811)	0.0112 (0.0736)	-0.6015* (0.0484)	-0.0162 (0.0443)
GED	-0.2290* (0.0230)	-0.3617* (0.0377)	-0.1048 (0.0862)	-0.4001* (0.1387)	-0.4136* (0.0615)	-0.1034* (0.0370)	-0.3426* (0.0533)	-0.1547* (0.0401)
YOR78	0.2008* (0.0210)	0.2305* (0.0343)	1.4310* (0.1142)	1.0559* (0.1412)	0.2427* (0.0695)	1.5900* (0.0590)	2.9178* (0.0988)	0.9749* (0.0506)
YOR79	0.0253 (0.0228)	0.1031* (0.0309)	0.7858* (0.1237)	0.6426* (0.1540)	-0.0469 (0.0711)	1.1096* (0.0618)	2.0118* (0.1013)	0.6211* (0.0526)
YOR80	-0.0061 (0.0232)	-0.0515 (0.0322)	0.6127* (0.1303)	0.4776* (0.1519)	0.0490 (0.0696)	0.8819* (0.0648)	1.5273* (0.1084)	0.5175* (0.0562)
C	1.7863* (0.0087)	1.8343* (0.0141)	1.8463* (0.0423)	2.0438* (0.0510)	1.6944* (0.0240)	1.7737* (0.0139)	1.2648* (0.0133)	1.8046* (0.0140)
GRD*DIR	0.0037	0.0263	0.0001	0.0004	0.0001	0.0379	0.2534	0.0001
LLF	-52519.9582	-21774.0642	-2855.6770	-2231.8764	-5417.4679	-20553.6762	-15369.5528	-17227.3148
NOBS	32941	12066	2235	1956	2825	16522	13768	10994

TABLE 2

DURATION MODEL COEFFICIENTS FOR E5 to E6 PROMOTIONS

BASE MODEL

	11B	19E	31V	54E	63B	71L	76Y
INT	-10.2967* (0.1480)	-11.7765* (0.2546)	-8.1477* (0.9813)	-8.9233* (0.3293)	-14.8862* (0.3383)	-11.3869* (0.3561)	-8.5093* (0.2632)
EDUC	0.1061* (0.0113)	0.1646* (0.0199)	0.1466 (0.0770)	0.0420 (0.0235)	0.1242* (0.0235)	0.1928* (0.0227)	0.0695* (0.0196)
AFQT	0.0057* (0.0004)	0.0052* (0.0007)	0.0088* (0.0027)	0.0060* (0.0010)	0.0080* (0.0008)	0.0123* (0.0011)	0.0048* (0.0009)
MSTAT	-0.0060 (0.0269)	-0.0312 (0.0403)	-0.1076 (0.1734)	0.2646* (0.0723)	0.1017 (0.0645)	0.2643* (0.0629)	0.0346 (0.0500)
RACE	-0.0511* (0.0198)	-0.0304 (0.0385)	0.0141 (0.1227)	0.0302 (0.0499)	0.0306 (0.0436)	-0.2097* (0.0470)	-0.0195 (0.0368)
NDEP	-0.0336* (0.0073)	0.0111 (0.0125)	0.0671 (0.0457)	0.0058 (0.0186)	0.0591* (0.0134)	-0.0798* (0.0180)	-0.0101 (0.0157)
TIS	0.0179* (0.0002)	0.0222* (0.0004)	0.0182* (0.0020)	0.0186* (0.0009)	0.0245* (0.0004)	0.0059* (0.0011)	0.0102* (0.0007)
SEX	**** ****	**** ****	-0.6595 (0.6152)	-0.4767* (0.1270)	-0.4502* (0.2269)	-0.6612* (0.0668)	-0.3562* (0.0723)
GED	-0.0403 (0.0220)	-0.0035 (0.0334)	0.0345 (0.1318)	0.1117* (0.0551)	-0.0280 (0.0340)	-0.2254* (0.0700)	-0.0462 (0.0462)
YOR77	1.3784* (0.0333)	0.9639* (0.0441)	3.6891* (0.2098)	1.4540* (0.0828)	2.6453* (0.1452)	2.0817* (0.1134)	1.5024* (0.0598)
YOR78	1.0002* (0.0333)	0.6444* (0.0524)	1.8551* (0.2543)	1.0535* (0.0884)	2.0647* (0.1541)	1.0484* (0.1281)	1.0106* (0.0609)
YOR79	0.6914* (0.0330)	0.4979* (0.0481)	1.4078* (0.2267)	0.7846* (0.0811)	1.4226* (0.1464)	0.6247* (0.1279)	0.7279* (0.0646)
C	2.0156* (0.0124)	2.2363* (0.0214)	0.7054* (0.0309)	1.7065* (0.0259)	2.2852* (0.0213)	1.5070* (0.0231)	1.6262* (0.0160)
GRD*DIR	0.0405	0.0003	0.0009	0.0001	0.1741	0.0004	0.0003
LLF	-24488.1578	-10373.1817	-1328.5505	-4188.5707	-9091.6666	-9107.3756	-10984.5066
NOBS	17303	7715	1093	2559	7972	7326	6501

TABLE 3
PROJECTED TIME TO PROMOTION
BASE MODEL
E4 to E5

FEMALES

AFQT	HIGH				LOW			
RACE	WHITE		BLACK		WHITE		BLACK	
EDUC	NONHS	HSDG	NONHS	HSDG	NONHS	HSDG	NONHS	HSDG
31V	48.64 (7.33)	45.99 (6.78)	48.63 (7.39)	45.97 (6.80)	51.61 (7.83)	48.79 (7.26)	51.59 (7.82)	48.78 (7.22)
54E	28.68 (1.55)	23.76 (1.16)	28.79 (1.61)	23.85 (1.16)	29.95 (1.59)	24.81 (1.21)	30.07 (1.56)	24.91 (1.11)
63B	54.57 (2.43)	46.60 (1.94)	50.70 (2.39)	43.29 (1.90)	61.25 (2.72)	52.34 (2.20)	56.93 (2.62)	48.63 (2.09)
71L	135.49 (2.76)	116.49 (2.98)	138.42 (2.69)	120.21 (2.93)	144.62 (2.35)	128.27 (2.73)	147.06 (2.18)	131.53 (2.51)
76Y	40.98 (1.21)	36.81 (0.97)	40.87 (1.25)	36.71 (0.98)	43.36 (1.27)	38.94 (1.02)	43.24 (1.22)	38.83 (0.94)

MALES

AFQT	HIGH				LOW			
RACE	WHITE		BLACK		WHITE		BLACK	
EDUC	NONHS	HSDG	NONHS	HSDG	NONHS	HSDG	NONHS	HSDG
11B	26.95 (0.24)	24.29 (0.16)	28.14 (0.36)	25.36 (0.26)	30.51 (0.26)	27.50 (0.19)	31.85 (0.35)	28.70 (0.26)
19E	23.04 (0.31)	20.50 (0.20)	22.73 (0.43)	20.22 (0.31)	25.54 (0.31)	22.72 (0.21)	25.19 (0.41)	22.41 (0.29)
31V	38.74 (1.73)	36.63 (1.39)	38.73 (2.12)	36.61 (1.72)	41.11 (1.78)	38.86 (1.47)	41.09 (2.03)	38.85 (1.64)
51B	44.86 (2.61)	36.19 (1.34)	47.00 (3.35)	37.92 (2.14)	51.65 (3.01)	41.67 (1.60)	54.11 (3.49)	43.66 (2.12)
54E	26.77 (0.81)	22.18 (0.57)	26.88 (1.04)	22.27 (0.71)	27.96 (0.80)	23.16 (0.59)	28.07 (0.91)	23.25 (0.60)
63B	54.92 (1.16)	46.90 (0.89)	51.02 (1.31)	43.56 (0.99)	61.64 (1.19)	52.67 (0.90)	57.29 (1.25)	48.93 (0.91)
71L	110.42 (3.14)	87.39 (2.80)	114.31 (3.21)	91.60 (2.93)	122.84 (2.88)	101.22 (2.86)	126.33 (2.75)	105.31 (2.73)
76Y	40.62 (0.88)	36.48 (0.70)	40.51 (0.98)	36.38 (0.76)	42.97 (0.90)	38.59 (0.71)	42.86 (0.89)	38.49 (0.66)

TABLE 4
PROJECTED TIME TO PROMOTION
BASE MODEL
E5 to E6

FEMALES

AFQT	HIGH				LOW			
RACE	WHITE		BLACK		WHITE		BLACK	
EDUC	NONHS	HSDG	NONHS	HSDG	NONHS	HSDG	NONHS	HSDG
31V	152.38 (15.74)	151.41 (15.87)	152.03 (16.27)	151.05 (16.32)	157.40 (13.17)	156.58 (13.32)	157.10 (13.55)	156.28 (13.63)
54E	54.86 (4.18)	57.06 (4.17)	53.90 (4.24)	56.07 (4.16)	59.83 (4.64)	62.21 (4.66)	58.79 (4.58)	61.14 (4.52)
63B	115.39 (9.24)	112.41 (9.26)	114.20 (9.41)	111.21 (9.40)	123.01 (8.92)	120.13 (9.03)	121.86 (9.06)	118.97 (9.15)
71L	143.48 (3.19)	132.00 (3.16)	149.41 (2.82)	139.31 (2.82)	151.91 (2.69)	142.46 (2.84)	156.65 (2.27)	148.52 (2.37)
76Y	60.63 (2.88)	57.82 (2.50)	61.34 (2.93)	58.51 (2.52)	65.12 (3.12)	62.14 (2.75)	65.88 (3.08)	62.87 (2.68)

MALES

AFQT	HIGH				LOW			
RACE	WHITE		BLACK		WHITE		BLACK	
EDUC	NONHS	HSDG	NONHS	HSDG	NONHS	HSDG	NONHS	HSDG
11B	40.49 (0.52)	38.39 (0.42)	41.53 (0.63)	39.38 (0.51)	43.48 (0.56)	41.23 (0.46)	44.60 (0.64)	42.29 (0.49
19E	40.14 (0.66)	37.73 (0.53)	40.69 (0.92)	38.25 (0.75)	42.57 (0.69)	40.01 (0.58)	43.15 (0.87)	40.56 (0.70
31V	131.15 (6.90)	129.59 (6.14)	130.58 (8.10)	129.01 (6.98)	139.35 (5.80)	138.00 (5.29)	138.86 (6.50)	137.49 (5.57
54E	41.51 (1.52)	43.19 (1.34)	40.78 (1.79)	42.43 (1.53)	45.31 (1.70)	47.14 (1.57)	44.52 (1.80)	46.32 (1.54
63B	97.77 (3.56)	94.82 (3.40)	96.59 (3.81)	93.65 (3.61)	105.62 (3.56)	102.61 (3.45)	104.42 (3.71)	101.41 (3.57
71L	119.29 (3.99)	104.03 (3.32)	127.83 (3.88)	113.55 (3.38)	131.59 (3.54)	117.86 (3.20)	138.95 (3.22)	126.52 (2.94
76Y	48.82 (1.61)	46.52 (1.22)	49.41 (1.67)	47.08 (1.26)	52.53 (1.65)	50.06 (1.26)	53.16 (1.62)	50.66 (1.18

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Manpower and Personnel Policy Research Group

Working Paper MPPRG 89-02

ASSIGNING NON-GRADS TO MINIMIZE ATTRITION

ROY NORD

CYRIL KEARL

JANUARY 1989

Reviewed by:

David K. Horne
Acting Leader, Manpower and Personnel Planning Team

Approved by:

Curtis L. Gilroy
Chief, Manpower and Personnel Policy Research Group

MANPOWER AND PERSONNEL RESEARCH LABORATORY

DRAFT

U.S. ARMY RESEARCH INSTITUTE
FOR THE BEHAVIORAL AND SOCIAL SCIENCES
5001 Eisenhower Avenue, Alexandria, VA 22333-5600

P89-0264

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ASSIGNING NON-GRADS TO MINIMIZE ATTRITION

QUESTION

It appears that an increase in non-HSDG accessions over 1988 levels will be required to meet FY89 accessions goals. It has been well established that non-hsdg recruits are much more likely to attrit before completing their first term. What can be done to minimize the effect of the additional non-grad accessions on first-term attrition rates?

BACKGROUND

Previous ARI research (e.g., Manganaris and Schmitz, 1984) has suggested that the differential between attrition rates for grads vs non-grads varies significantly across MOS. If this is true, then it should be possible to mitigate the effects of an increase in non-grad accessions by channelling non-grads into MOS where the attrition differentials are smallest, and reducing the numbers of non-grads assigned to MOS where the differentials are high. The purpose of this analysis is to (a) determine whether cross-MOS differences in grad/non-grad attrition rates are stable over time; (b) if so, to classify MOS in terms of their suitability for non-grads; and (c) to determine the number of non-grads that can be accommodated in these MOS and roughly estimate the impact of these additional accessions on overall attrition rates.

APPROACH

Step 1: Stability analysis. Preliminary analyses of attrition data for accessions cohorts over the period 1982-1985 showed considerable instability in MOS differences in HSDG/non-HSDG attrition rates over time. This appears be true for three main reasons: First, because of variations over time in other factors that affect attrition rates such as proportion of two year seats, proportion of female accessions and AFQT distributions; Second, because of variations across MOS in the reliability of the relationship between HSDG status and attrition; and third, because of changes in policies and practices within MOS from year to year. We did not have access to the information required to control for the third factor, but we were able to at least partially address the first two factors.

We controlled for variations in applicant characteristics by estimating separate multiple logistic regression equations for each MOS in each year, as well one equation for each MOS using the pooled data from all three years. (Note: In order to do this the analysis was restricted to those MOS that had at least 30 non-grad accessions in two of the three years. The resulting sample covered 50 MOS with roughly 85,000 NPS accessions.) The equations included terms for black, female, I-IIIA, and two-year enlistees as well as HSDG status. This approach provided a considerable increase in the stability of the HSDG differential

across years. Stability was further increased by adjusting each coefficient by its standard error (using the upper 95% confidence limit of the coefficient rather than its mean). By using the adjusted coefficients, we were able to obtain a set of rank orderings of the MOS in our sample that were generally consistent across all three years.

Step 2: MOS classification. To classify the MOS in terms of their suitability for non-grads, we first examined the results of the year-by-year regression equations and grouped the MOS into four groups: Group I includes MOS with consistently very low differentials. Group II contains MOS with somewhat higher differentials that were nevertheless consistently below average. Group III is made up of MOS with differentials that were either consistently above average or unstable across years. Group IV is the MOS with consistently high differentials. We then used the pooled adjusted coefficient estimates to obtain a similar grouping, and compared these groups with those obtained from the single year estimates. The composition of the groups was virtually identical, thus allowing us to use the pooled estimates as both a basis for classification and to estimate the attrition impacts of various allocations of non-grads across the four groups. Summary descriptions of the groups are provided in Table 1. The last column of this Table provides the estimated percentage change in attrition that will result from a five percent increase in the proportion of non-grads in each group. Tables 2-5 show the MOS in each group.

Step 3: Recommended allocations and feasibility analysis. The recommended allocations for each group are "rule-of-thumb" estimates. We began with an assumption that extremely large changes in non-grad content are probably inadvisable on the basis of our results as well as infeasible. We therefore limited the maximum proportion of non-grads to 30% for Group I. Our tentative recommendation for Group II is 20% maximum non-grad fill. For Group III, which includes MOS which show significant variability across years as well as those with somewhat higher than average differentials, we suggest a maximum of 10% -- slightly below the historical average of 11.5% for the 1982-1985 period in these MOS. Finally, we suggest a maximum of 5% non-grad content in the Group IV MOS, which show consistently high differentials between grad and non-grad attrition rates. A more precise, and somewhat more efficient allocation could be obtained by using an optimization procedure to obtain rates, either by group or for each MOS. Time constraints have precluded such an exercise for this analysis, but this could be easily done.

To determine the overall potential for added FY89 non-grad accessions resulting from this proposal, we needed to account for the fact the MOS are already partially filled. To do this, we subtracted the current MOS fill, as of 31 December 1988 from the total FY89 NPS accessions target, and then used the minimum of this number and the suggested percentage of total accessions as our suggested non-grad fill for the remainder of FY89. The result is a total non-grad content for the 50 MOS of 11,938,

roughly 14% of total accessions in these MOS. The numbers for each group appear in Tables 2-5.

RESULTS

Table 6 summarizes the predicted attrition effects of the suggested allocation and compares these to the rates that would occur if the same number of non-grads were allocated across MOS in the same way they were over the 1982-1985 period. The rates in Table 6 are predicted percentage changes in attrition rates that would result from an increase in non-grad content in these MOS from 11.5% (the 82-85 average) to 14.1% (our suggested feasible fill). The suggested allocation will increase expected attrition in the Group I and II MOS, but that this increase will be more than offset by reductions in Groups III and IV. Overall, the results indicate the increase from 11.5% to 14.1% would increase attrition by 1.93% if historical allocation patterns were followed, but that reallocation could actually reduce the rate by .87%. If one assumes a rate for 11.5% non-grads of 30% attrition, this translates into new rates of 30.6% versus 29.9% for 14.1% non-grad content, or a difference of roughly 590 attritions in these MOS.

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Table 1. Summary of MOS Attrition Groups

Nongrad Attrition Group	Number of MOS	Target Accessions	Percent Empty	5% nongrads increases % attrition
I.	9	5247	36%	0.7%
II.	12	32680	44%	1.0%
III.	18	34613	51%	1.1%
IV.	11	11920	42%	1.3%
Total	50	84460	46%	1.1%

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Table 2. MOS with Lowest Non-Grad Attrition (Group I)

MOS	Target Accessions	December Fill	Empty Seats	Suggested Non-Grad Target
62E	543	412	131	131
63Y	405	192	213	118
62B	481	286	195	139
43E	561	405	156	156
63N	114	78	36	27
63D	378	158	220	112
63T	1021	513	508	303
52C	355	192	163	106
76V	1389	1105	284	284
Total	5247	3341	1906	1377
YTD. Non Grad Fill				88
Total Non Grad Fill				1465

Of the empty seats 72% should be filled with non-grads. The result will be 28% of these MOS will be filled with non-grads.

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Table 3. MOS with Lower Non-Grad Attrition (Group II)

MOS	Target Accessions	December Fill	Empty Seats	Suggested Non-Grad Target
71L	1423	1266	157	157
31K	1829	970	859	342
16R	610	257	353	106
55B	789	401	388	154
11X	17425	9895	7530	2164
94B	3347	1539	1808	597
75D	136	118	18	18
13M	696	276	420	135
88M	4804	2704	2100	739
82C	510	356	154	99
63E	610	299	311	121
15E	501	271	230	76
Total	32680	8352	14328	4708
YTD. Non Grad Fill				171
Total Non Grad Fill				6424

Of the empty seats 33% should be filled with non-grads. The result will be 20% of these MOS will be filled with non-grads.

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Table 4. MOS with Higher Non-Grad Attrition (Group III)

MOS	Target Accessions	December Fill	Empty Seats	Suggested Non-Grad Target
63B	3406	1730	1676	204
13F	1290	853	437	54
13B	4831	3117	1714	203
16X	1095	439	656	81
54E	1317	684	633	106
91A	4206	3328	878	384
19D	2404	999	1405	139
16P	456	241	215	20
19X	3654	1925	1729	342
52D	1427	719	708	129
16S	1063	724	339	40
95B	4600	3275	1325	434
12C	408	265	143	38
63W	1178	793	385	111
45K	227	139	88	22
63H	613	321	292	59
72E	848	473	375	81
76C	1590	823	767	141
Total	34613	20848	17530	2587
YTD. Non Grad Fill				875
Total Non Grad Fill				3462

Of the empty seats 19% should be filled with non-grads. The result will be 10% of these MOS will be filled with non-grads.

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Table 5. MOS with Highest Non-Grad Attrition (Group IV)

MOS	Target Accessions	December Fill	Empty Seats	Suggested Non-Grad Target
31M	1061	566	495	44
63S	1050	575	475	48
31C	1861	1108	753	21
31V	1060	573	487	45
12B	3528	1918	1610	84
76Y	2148	1205	943	86
62F	219	167	52	9
44N	45	25	20	0
67N	392	404	0	0
67Y	362	227	135	18
67V	194	193	1	1
Total	11920	6961	4959	357
YTD. Non Grad Fill				219
Total Non Grad Fill				576

Of the empty seats 7% should be filled with non-grads. The result should be 5% of these MOS will be filled with non-grads.

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Table 6. The Effect on Attrition of Increasing Non-grads from 11.5% to 14.1%

Non-grad Attrition Groups	Percentage Change in Attrition basing assignment of nongrads on	
	Traditional patterns	ARI Suggested patterns
Lowest	1.51%	7.56%
Lower	1.75%	1.69%
Higher	2.02%	-2.74%
Highest	2.42%	-7.27%
Total	1.93%	-0.87%

Manpower and Personnel Policy Research Group

Working Paper MPPRG 88-57

ESTIMATING THE BENEFITS AND COSTS OF

CLASSIFICATION AND ASSIGNMENT SYSTEMS

ROY NORD AND EDWARD SCHMITZ
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Reviewed by:

Approved by:

Curtis L. Gilroy
Chief, Manpower and Personnel
Policy Research Group

Cleared by:

NEWELL K. EATON, Director

Manpower and Personnel Research Laboratory

U. S. Army Research Institute for the Behavioral and Social Sciences
5001 Eisenhower Avenue, Alexandria, VA 22333-5600

I. INTRODUCTION

Operations research has developed many techniques to improve the matching of soldiers, sailors, and airmen with military skill requirements. Two important questions must be asked of any proposed changes to classification and assignment systems:

- o What improvements will be generated by policy changes?

- o Will the improvements be worth implementing?

This paper provides a framework for addressing these questions for Army recruit classification and assignment. First, several alternative policies are identified for consideration. Then, simulations are performed which answer the first of these questions: how each alternative is likely to affect predicted soldier performance. Finally, two models are developed to assess the benefits of improved performance. Both of these methodologies find that there are substantial benefits that can be achieved through an improved assignment system.

II. SIMULATING PREDICTED PERFORMANCE CHANGES

Recruit assignment has two objectives. First, all training seats must be filled. Second, one desires to fill seats with the best performing candidates available.

This section presents and describes the results of a series of simulations of the assignments that would result under different assignment policies. Two kinds of realistic policies are considered, the Army's current classification and assignment system and the Enlisted Personnel Allocation System (EPAS), described in Schmitz and McWhite (1986). Finally, policies which are not necessarily "realistic" are also investigated. That is, the performance gains they indicate might not actually be achieved in practice. However, these alternatives provide useful information on the way information on the predicted performance of recruits is used, and can aid in the interpretation of more operational models.

The policies simulated were as follows:

1. Random Assignment. Recruits were randomly placed into jobs. There is no attempt to use classification information.

2. Assignment with Current Job Standards. Classification information is available and job qualifying standards are in use. Candidates are assigned to jobs sequentially (that is, in the order they actually enlisted) using the current assignment system. However, job standards are generally below the selection standards — that is, most of recruits in the sample meet the minimum standards for most jobs, and virtually all recruits met the standard for at least one job.

3. Efficient Assignment with Current Job Standards. Candidates are sequentially assigned to jobs using EPAS. While job standards are relatively

low, substantial weight is placed on maximizing predicted performance. This alternative also used information on the predicted probability of completing at least on full term of service (which varies with the job assignment) to minimize predicted attrition.

4. Optimal Placement. A group of candidates are assigned to jobs as a batch (that is, as if the entire population of recruits could be optimally matched with the entire set of job openings in a single simultaneous operation). A straightforward linear programming routine was used to simulate this alternative.

5. Maximum Placement. Candidates are placed into jobs for which they have the highest aptitude and specific job requirements are ignored.

The maximum placement scenario was included to allow us to establish a ceiling against which other approaches could be compared. This policy is expected to provide results similar to the Brogden (1959) estimate of the potential gains in the allocation average. The random assignment policy provides a corresponding "floor". The optimal placement scenario provides an assessment of the level of performance that could be achieved with this population while meeting actual MOS demands, if perfect information about supply and demand was available. The difference between maximum and optimal placement indicates the degree to which Brogden's assumptions overestimate the potential gains.

Finally, to assess the payoff from simply changing job standards rather than the assignment system, scenarios are evaluated that include different

occupational entrance standards. First, classification information is used as in the previous examples, but all job standards were raised by 5 aptitude area points on the composite scale (.25 standard deviations) to be more in alignment with selection standards. Then job standards were increased by .5 standard deviations, or to the point where they are generally higher than the selection standards. Note, that all of the scenarios assume that applicants will enter the jobs to which they are assigned.

III. DEVELOPING A SIMULATION MODEL

A key aspect of job assignment research is the development of criteria for measuring performance. Indicators that have been used in the past include attrition (Fernandez and Garfinkle 1985, Nelson and Schmitz 1985), training performance, Skill Qualifications Test (SQT) scores (Schmitz and Nelson 1984, Fernandez and Garfinkle 1985), promotion (Butler 1976) and performance on job simulations (Nelson et al. 1985). Other criteria which have been considered include supervisor ratings, long-term retention, payroll costs, and achievement of awards and honors (or dishonors). Still further complexity is introduced if aggregate or organizational levels of performance are considered.

We use two criteria of job performance:

- SQT performance

- Probability of completing the enlistment tour.

These two factors measure two major aspects of first term job performance: how well the person performs his or her job technically and how long he or she is likely to perform it. The analysis is limited to performance gains over the initial enlistment term. First of all, this is largely the period affected by the assignment decision. Most soldiers do not remain beyond the first enlistment. Also, reenlistment eligibility is largely determined by actual job performance, not performance predicted at the entry level.

The nine aptitude area scores used for job assignment are the predictors of technical job knowledge used in this analysis. The validities with job performance criteria were obtained from Zeidner (1987).

Considerable work has been performed on attrition and its relationship to various predictors available at the time of enlistment. Studies have identified gender, education, AFQT, race, age, geographic region, and participation in the DEP as factors that can significantly affect attrition. Research by Buddin (1981), Eaton and Nogami (1981), Baldwin and Daula (1985), and Manganaris and Schmitz (1984, 1985) has all shown how attrition patterns also vary considerably by occupation in the Army.

In this analysis we use attrition rate estimates developed by Manganaris and Schmitz (1984) as the criteria for analysis. This model includes MOS, AFQT, gender, occupation, and education as factors affecting attrition rates. The model develops expected attrition rates for all MOS and has been incorporated into EPAS. Thus, it can easily provide the kinds of results desired in this analysis.

Simulation Results

The simulations were carried out by assigning a random sample 5000 recruits from the 1984 Army accession population to all 275 entry level MOS under each policy, and examining the predicted job performance resulting from each policy. Table 1 presents the results of the gains in job performance predictors that result from the alternative assignment policies developed above.

The Army's current assignment system produced an average aptitude area score of 107.5 for the job a recruit was actually assigned -- a gain over random assignment of 1.4 points or .07 standard deviations.

There are several reasons for this relatively small increase over a random assignment policy. First, the operational system is dominated by concerns other than maximizing job performance. The majority of emphasis is placed upon filling requirements. A high penalty in terms of wasted training resources and lower organizational productivity is paid by the Army if it fails to fill available training seats. In addition, the Army has restrictions on which MOS women may enter and the number who may enter many occupations as well as AFQT distributional requirements for all MOS to insure that no job is entirely filled with minimally qualified individuals. Thus, with the uncertainties of a sequential placement system, high weight is placed upon simply filling all job demands.

Largely because of these considerations, classification information has

little effect on decisions in the present system. Test scores tend to be used primarily to assure that assignees meet minimum job standards. Given that the average candidate greatly exceeds the average qualifying score, standards do little to maximize expected job performance.

The results of the EPAS assignment simulations show that, while the average predictor score that could be achieved in practice is lower than that resulting from the optimal placement scenario, the expected gain over random assignment achieved by using EPAS ranges from 3.87 to 4.22 aptitude area points, depending on the job standards used. This represents a gain of more than twice the difference between the current system and a policy of random assignment of the recruit population. Furthermore, these gains are made more valuable by a reduction in predicted attrition rate of 0.4 percent.

IV. ESTIMATING THE VALUE OF PRODUCTIVITY GAINS

For purposes of selecting a system design, it may be sufficient to simply rank the results among alternatives. However, many alternatives either incur substantial costs or could be disruptive to current operating procedures. In these cases it is important to convert alternatives into a common metric for comparison.

The most commonly used metric for making such comparisons is dollars. While this may not always be the most appropriate measure, it is frequently called upon when resource decisions are made. Both personnel psychology and economics/operations research have provided approaches for estimating the benefits and costs of classification and assignment. Examples of each

approach are used to evaluate the above policy alternatives.

Personnel Psychology

Psychologists have long recognized the relationship between improvements in the prediction of job performance and organizational productivity. The origins of research into this relationship can be traced to work by Taylor and Russell (1939) and Brogden (1949). Recently there has been considerable work done to refine and extend these ideas and apply them to employee selection in both the public and private sectors (see, e.g. Schmidt et al. (1985), and Cronbach and Gleser (1965)).

A key innovation from Brogden was the development of an equation for evaluating the impact of a selection test on organizational productivity. His equation was:

$$U = N\ v\ SD_y\ Z$$

where U is the gain in organizational productivity;

v is the validity of the predictor (correlation with the performance criterion);

N is the number of individuals selected;

SD_y is the value to the organization of one standard deviation of performance; and

Z is the expected mean predictor score (expressed as a standard normal deviation) resulting from a given selection standard.

This formula provided a systematic way to assess the impact of selection tests. For a considerable time, however, very little work was performed in this area, primarily because of the perceived difficulty of assigning a

dollar value to a standard deviation in performance.

After considerable experimentation with a variety of approaches, a rough consensus appears to have been reached that the most practical method for obtaining estimates of the dollar value of performance is through the use of expert judgement (Hunter and Schmidt, 1982). This approach relies on assessments elicited from individuals in a position to evaluate the organizational consequences of variations in job performance. These individuals are asked to estimate the dollar value of selected levels of performance. By imposing distributional assumptions on both the error in these judgments and the variations in job performance it is possible to arrive at estimates of the dollar value of a standard deviation in performance.

Recent research by Schmidt et al. (1985) has shown that, in a wide variety of such surveys, the estimates of the value of a standard deviation of performance tend to fall in the range of 40 to 70 percent of salary. This finding has led to widespread use of a "rule of thumb" of 40% of salary as a conservative estimate of the value of a standard deviation change in expected mean performance.

Economics and Operations Research

An economic approach to evaluating the costs and benefits of employee selection was provided by Armor et al. (1982). This approach focuses on "opportunity costs" as a measure of the value of a selection procedure. In effect, this method argues that the value of achieving a given improvement in

performance through more effective selection, classification and assignment procedures is at least equal to the cost of achieving the same improvements by lowering the selection ratio. This approach differs from earlier psychological utility models in two ways.

The first major difference is its recognition that increased selectivity imposes costs other than those involved in designing and administering the selection instrument. Most of the psychological models of selection utility either implicitly or explicitly assume that the number of job applicants is infinite, and thus the only costs associated with increased selectivity are those required to develop the selection instrument and process applicants. Armor explicitly assumed that productivity gains from higher job standards would require larger recruiting costs. This is likely to be true for two reasons: First, there are likely to be non-zero costs associated with attracting applicants, and since increased selectivity will require the employer not only to process but also to attract a larger pool of applicants reducing the selections ratio will increase these costs. Second, to the extent that the abilities measured by the selection test are in general demand, the cost <u>per applicant</u> will also increase as the system becomes more selective.

This issue is of critical importance in the evaluation of selection policies, but it also provides a means to assess the value of improved classification and assignment policies under a given selection strategy. Brogden noted this effect when he stated that an increase in the allocation average was equivalent to an increase in the selection ratio (Brogden, 1959).

The second difference between Armor's approach and most earlier efforts was its use of time as a component of job performance value. A measure was constructed that included both technical job performance and employee turnover. This indicator, "qualified man months", weights the probability that a selected recruit will perform at or above a given standard by the expected duration of that level of performance. The inclusion of the time component of performance provides a convenient way to combine the effects of policies that affect both performance and attrition rates. However, in this application, the advantage is obtained by replacing a continuous measure of performance with a discrete standard similar to that used by Taylor and Russell.

A considerably more extensive approach to the incorporation of performance duration was developed by Boudreau and Berger (1985). They argue that the proper use of estimated dollar values for a standard deviation of performance, it is necessary to take into account a number of factors other than the estimates themselves. These include:

- the average length time over which the performance will be provided
- compensation over that period
- the discount rate
- projected salary increases over the relevant period.

Results of Estimating Productivity Gains

We use two variations on the methods described above to evaluate the benefits of the simulation results described above. Method 1 is a direct application of the procedure recommended by Boudreau and Berger, using the "40 percent" rule of thumb of Schmidt, et al. as our estimate of the dollar value of a standard deviation of performance. The only "new twist" in this application will be the incorporation of predicted values for the expected duration of performance generated by the EPAS simulations.

We assume that the relevant time period is the average length of first term service. Most soldiers do not serve beyond the initial term. Further, it is assumed that reenlistment eligibility decisions are made primarily on the basis of observed performance, not performance predicted at the entry point.

The average enlistment term in 1984 was 3.27 years. However, about 36 percent of recruits under the current assignment system will fail to complete their first term. The expected attrition rates under the optimal assignment alternatives are as shown in Table 4. Since nearly all attrition occurs either during or shortly after training, we also assume that the time served by attritees is nonproductive. This yields an average productive duration of 2.09 years per accession or 64 percent of the average enlistment tour under the current system. Comparable values under the simulated alternatives are presented in Table 4 under Method 1.

There are many different estimates of salary for military personnel,

since housing and subsistence allowances are separate from basic pay. One frequently used measure of salary is regular military compensation, which includes basic pay, subsistence allowance, basic allowance for quarters, variable housing allowance, and the tax advantage that comes from tax-free allowances. Based upon a typical rank progression, a recruit would earn an average RMC of $48,686 over the average 3.27 year enlistment term.

The discount rate and the salary growth rate affect the present value of salary. We assume a discount rate of 8.5 percent and a salary growth rate of 4 percent. This produces a net discount rate of 4.5 percent is the resulting factor. Applying this rate to the projected RMC stream yields a discount multiplier of .904.

The 40 percent of salary used by Schmidt et al. (1985) is assumed as the relationship of salary to SD_y. Combining all of the above factors, the estimated dollar value of the performance gains under each alternative is:

$$U^j = (.904)(.4)(\$48{,}686)\ t^j \sum_{i=1}^{9} n_i v_{ij} z_{ij}$$

The dollar values of the gains from the simulated realistic policies estimated by this method are presented in Table 3.

Method 2 explores an amalgam of the approach used by Armor. For this method, we use the predicted attrition probabilities and the predicted performance scores from the simulations to generate a continuous measure of quantity and quality of performance. We then calculate the number of additional recruits in the upper half of the AFQT distribution (test

categories I-IIIA) that would be required under the current classification and assignment system to obtain the same value for this measure obtained under each simulated policy. (To do this, we assume that the distribution of attrition rates and predicted performance among the additional I-IIIA's would be the same as it is among the 1984 I-IIIA population.) We then use estimates from previous research on the cost per recruit of replacing Category IIIB and IV recruits with the higher quality recruits as our estimate of the dollar value of the benefits provided by the simulated policy.

One recent estimate of the opportunity costs of obtaining I-IIIAs comes from the enlistment bonus experiment. Polich et al. (1986) estimate that it would cost about $16,000 for each additional high quality recruit obtained via bonuses.

The results of the simulations evaluated using the opportunity cost approach are shown in Table 3 under the heading "Method 2". The results also indicate that the net benefit of implementing EPAS (policy 3) over the current system (policy 2) would produce nearly 50 million dollars worth of improved performance. Furthermore, these results are robust; even if job standards are raised substantially over the present levels, the net benefits remain in excess of thirty million dollars.

V. DISCUSSION

Simulations provide a useful way to evaluate the outcomes of classification and assignment improvements. They can provide realistic estimates of a wide range of policy alternatives. Furthermore, the simulations can be easily modified to include different objectives and constraints.

There are many problems in converting classification and assignment improvements into dollar values. However, both psychology and economics provide reasonable approaches for estimating the value of improved personnel policy.

In the case of EPAS, simulations indicated that the net benefits would far exceed the operating costs of 0.6 million per year. This would result in a benefit-cost ratio on the order of 50 for both benefit evaluation techniques. Thus, EPAS would produce a very high return on investment under any evaluation scheme.

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Table 1
Average Aptitude Area Scores and Predicted Performance Levels
Under Alternative Selection and Classification Strategies

	CURRENT STANDARDS		RAISED 5 POINTS		RAISED 10 POINTS	
	AA SCORE	PRED PERF	AA SCORE	PRED PERF	AA SCORE	PRED PERF
POLICY 1	106.1	0.202	106.76	0.225	107.63	0.254
POLICY 2	107.5	0.218	108.74	0.249	109.75	0.279
POLICY 3	109.97	0.237	110.75	0.26	111.85	0.292
POLICY 4	113	0.266	114.01	0.295	115.27	0.336
POLICY 5	113.9	0.287	114.74	0.314	115.92	0.352

Table 2
Predicted Attrition Rates
Under Alternative Selection and Classification Strategies

	CURRENT STANDARDS	RAISED 5 POINTS	RAISED 10 POINTS
POLICY 1	0.309	0.307	0.305
POLICY 2	0.306	0.305	0.303
POLICY 3	0.305	0.304	0.302
POLICY 4	0.303	0.301	0.299
POLICY 5	0.301	0.300	0.298

Table 3
Estimated Net Value of Performance Gains
Using Two Evaluation Methods*
(In millions of dollars)

	CURRENT STANDARDS		RAISED 5 POINTS		RAISED 10 POINTS	
	METHOD 1	METHOD 2	METHOD 1	METHOD 2	METHOD 1	METHOD 2
POLICY 1	-33.8	-44	-48.9	-50.1	-50.2	-105.2
POLICY 2	0	0	0	0	0	0
POLICY 3	33.4	49.5	18.4	37.3	23.2	31.3
POLICY 4	88.9	141.2	86.1	180.6	106.9	253.5

* Estimates for Policy 5 (Maximum Placement) are not provided because this policy produces allocations for which it is impossible to estimate expected changes in recruiting and training costs required to obtain a net value for performance gains.

Working Paper MPPRG 86-28

THE DELINKING OF ARMY COLLEGE FUND

AND ENLISTMENT BONUS BENEFITS:

THE IMPACT ON ENLISTMENTS

by

CHESTER PHILLIPS

April 1986

Reviewed by: EDWARD J. SCHMITZ

Approved by: CURTIS L. GILROY

U.S. Army Research Institute
for the Behavioral and Social Sciences
5001 Eisenhower Avenue, Alexandria VA 22333

INTRODUCTION

In order to achieve its recruiting missions, the Army must employ a set of enlistment options and incentives. Two of these are the enlistment bonus and the Army College Fund (ACF). These two programs have been used effectively as recruiting tools, attracting high quality individuals to the Army.

Until recently, an individual could have been eligible to receive both an enlistment bonus and the ACF for a four year enlistment tour in many MOS. In December 1985, however, Army recruiting policy was modified so that an individual could receive either an enlistment bonus or the ACF but not both. In this paper, responses from the Army Research Institute (ARI) recruit survey are used to estimate the possible enlistment effects of this policy change. These responses indicate that about 16 percent of eligible enlistees implied they would not have enlisted if both incentives were not available to them.

BACKGROUND

After a test program in FY81, the Army College Fund was instituted nationwide in FY82 (for details on the test program see Fernandez, 1982). The ACF enables the Army to provide educational incentives above the level available from the Veteran's Educational Assistance Program (VEAP) or currently, the New GI Bill. To obtain ACF benefits, the individual must already have contributed to the VEAP or new GI bill. Through the ACF, up to $14,400 in additional benefits are available to non-prior service AFQT I-IIIA high school graduates enlisting for four years in certain military occupational specialties (MOS). Smaller ACF benefits are available for shorter enlistment terms. The program has a twofold purpose. First, it is a market expander, attracting high quality individuals who would not otherwise consider the Army. Second, by limiting benefits to specific MOS, the Army can direct these high quality individuals where needed.

Enlistment bonuses are available to individuals enlisting in certain critical skills. In past years, about 45 MOS have included bonus eligibility. As is the case with the ACF, bonuses are intended to attract high quality individuals to the Army as well as specific MOS. Bonuses are generally only available to AFQT I-IIIA high school graduates enlisting for four year terms. Bonus levels vary by MOS, and are currently in the $2,00-8,000 range.

APPROACH

During the past several years, the U.S. Army Research Institute has surveyed new recruits upon entering the Army. Several of the survey questions pertain to bonuses and the ACF. In this paper, two particular survey questions will be examined:

- Suppose the job you signed up for did not pay an Army College Fund extra education bonus. What would you have done?
- Suppose the job you signed up for did not pay a cash bonus. What would you have done?

These two questions were asked to over 8,500 respondents. Respondents were given a choice of responses ranging from "Signed up for the same job anyway" to "Not enlisted at all". Responses to these two questions were examined simultaneously to determine how many individuals would not have joined the Army if both options had not been available. For this analysis, only those eligible for both options were selected. Eligibility was determined using the procedure developed by Elig, et al. (1984).

RESULTS

Approximately 1,250 respondents were found to be eligible for both options. Table 1 shows their joint responses to the two questions. The majority of the respondents (59.1 percent) would have joined the Army whether the two options were available or not. More importantly, 16.5 percent would not have joined had both options not been

available. On the basis of 47,500 eligible individuals yearly (estimate derived using FY83 contracts) this translates into a loss of over 7,800 accessions yearly (approximately 5.3 percent of total accessions). No statistically significant differences in responses were found between those signing for combat and non-combat MOS.

Caution must be used in the interpretation of these results. While it was shown that a decline in high quality enlistments could be projected if persons could not receive both options, the actual level of this decline may vary from the survey responses. Results should be validated against the most recent enlistment surveys when data become available, as well as against contracts signed since the delinking.

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Table 1

EFFECT OF BONUS AND ACF NON-AVAILABILITY ON ENLISTMENTS

		Enlistment Bonus	
		Enlist	Not Enlist
Army College Fund	Enlist	N=737 59.1%	N=135 10.8%
	Not Enlist	N=170 13.6%	N=205 16.5%

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Working Paper 84-10

AN OPERATIONAL MODEL FOR NEAR-TERM SUPPLY FORECASTING

BY CHESTER PHILLIPS AND EDWARD J. SCHMITZ

JULY 1984

U.S. Army Research Institute
for the Behavioral and Social Sciences
5001 Eisenhower Avenue, Alexandria VA 22333

EXECUTIVE SUMMARY

Requirement:

The U.S. Army Research Institute is currently developing an Enlisted Personnel Allocation System (EPAS). This system will ultimately provide the Army with an improved enlisted person-to-job match. Short-term personnel forecasts are necessary for the implementation of this system. This report examines several categories of individuals desired by the Army as well as the Army enlistment process itself, in order to develop a forecasting model to project near-term Army contracts.

Procedure:

Before a forecasting model could be developed, the enlistment process had to be clearly undertstood. Information was necessary concerning the appropriate forecast period, supply groupings, and point in the process to be forecast. Variables influencing the arrival of individuals within the system had to be examined. Several models were considered including exponential smoothing, and autoregressive model, ARIMA, OLS, and the use of recruiter missions themselves. The selected model was used to forecast male NPS AFQT cat I-IIIA high school graduate and senior contracts for the first quarter of FY84.

Findings:

The applicant to contract process was shown to consist of several steps (prospect, applicant, serious applicant, contract). Each of these steps had an associated loss rate. The process is usally completed in a relatively short time, with most completing the applicant-to-contract portion in a little over one week. Recruiter missions and economic conditions were found to influence the monthly

signing of contracts. This necessitated the forecasting of contracts rather than applicants or serious applicants. Since recruiter goals are allocated by reception station month, this was selected to be the forecast period. By the end of FY83 serious applicant to contract conversion rates were found to be approaching unity, indicating possible problems in meeting future goals. An OLS model was chosen with the explanatory variables recruiter goals and the interaction between goal achievement and male 16-21 unemployment lagged one month. The model performed well for the first quarter of FY84, with a total error of only 77 contracts.

Utilization of Findings:

This report indicates that the influence of recruiter missions necessitates forecasting contracts by reception station month, with forecast supply groups matching mission boxes. When modeling such a process, time series methods provide inadequate forecasts. The model used recruits missions, unemployment, and recruiting success as explanatory variables and provided accurate forecasts for FY84.

AN OPERATIONAL MODEL FOR NEAR-TERM SUPPLY FORECASTING

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I. INTRODUCTION

The Army is currently undertaking a major effort to redesign its personnel selection, classification, and allocation system. The finished products will provide data and methodologies that will enable the Army to maximize personnel job performance.

To optimally allocate contracts to MOS it is necessary to project the supply of contracts, especially in the near-term. Otherwise, desirable individuals may be turned away, inadequate people may enlist, or training seats could remain vacant. Each of these outcomes is highly undesirable.

Accordingly, this paper provides a detailed description of the applicant-contract process and the short-term forecasting problem. It investigates the key factors required by such a system. Based upon these factors, a recommended structure is given for a short-term forecasting model.

II. APPROACH

The approach will consist of the following steps:

1. Develop a descriptive quantitative model of the Army enlistment process.
2. Examine data concerning factors influencing the process.
3. Examine available short-term forecasting models.
4. Analyze data.
5. Develop specifications for a short-term forecasting model.

III. BACKGROUND

With the hardware used by the Army becoming increasingly more sophisticated, it is important to make efficient use of manpower resources. This can be accomplished through the use of an improved system of allocating persons to jobs. The current Army system emphasizes the need to fill particular military occupational specialties (MOS). Frequently, an MOS is given to the first qualified applicant desiring that position. With this type of person-MOS allocation system,

it is possible for an Army accession to be assigned to an MOS for which he is only marginally qualified. Conversely, a highly qualified individual may be assigned to a less desirable MOS because his or her preferred MOS has already been filled with lesser qualified individuals. In the extreme case, a highly qualified applicant may be lost to the Army altogether because his or her choice of MOS is not available.

The allocation system needs to account for the likelihood that a person who is highly qualified for a particular MOS will arrive in the near future. At the guidance counselor level, the current system stresses the filling of immediate training slots. While the quality mix of individuals within MOS is important, it is often treated secondarily to the filling of the slots themselves. Short-term forecasting would enable the Army to determine the types of persons arriving in the near future and therefore reserve the particularly attractive MOS for those most highly qualified. The offering of a desirable MOS to a highly qualified individual could also increase the probability of that applicant eventually signing a contract. Many of the lesser qualified applicants could be directed towards less easily filled MOS.

To join the Army, an individual must first meet certain mental and physical requirements. The Army currently uses the Armed Forces Qualification Test (AFQT) to determine whether an applicant is mentally qualified for enlistment. This exam, a segment of the Armed Services Vocational Aptitude Battery (ASVAB), tests an applicant's mathematical, verbal, and reading skills and is believed to be a good indicator of trainability [a formal discussion can be found in "Profile of American Youth", Office of the Assistant Secretary of Defense (Manpower, Reserve Affairs, and Logistics, 1982)]. Scores on the AFQT range from 1 to 99, with a median of 50. Those persons scoring 50-64 are categorized in category IIIA, those scoring 65-91 are considered in Category II and those scoring above 91 are included in AFQT category I. These three categories of individuals are considered to be those most desirable for entry level MOS.

This paper concentrates primarily upon those categories of individuals traditionally considered to be both supply constrained and highly desirable for Army jobs. This includes male high school graduates(HSG) and high school seniors (HSSR) without prior military experience in AFQT categories I-IIIA. During the period examined (FY81-83) the Army had their greatest success since the establishment of

the All Volunteer Force in attracting these upper category non-prior service high school graduates. During FY81 approximately thirty one percent of the over 100,000 male non-prior service contracts came from these categories. These percentages increased to forty five and forty nine percent of the total number of contracts in FY82 and FY83, respectively. This upward trend may not be permanent, however.

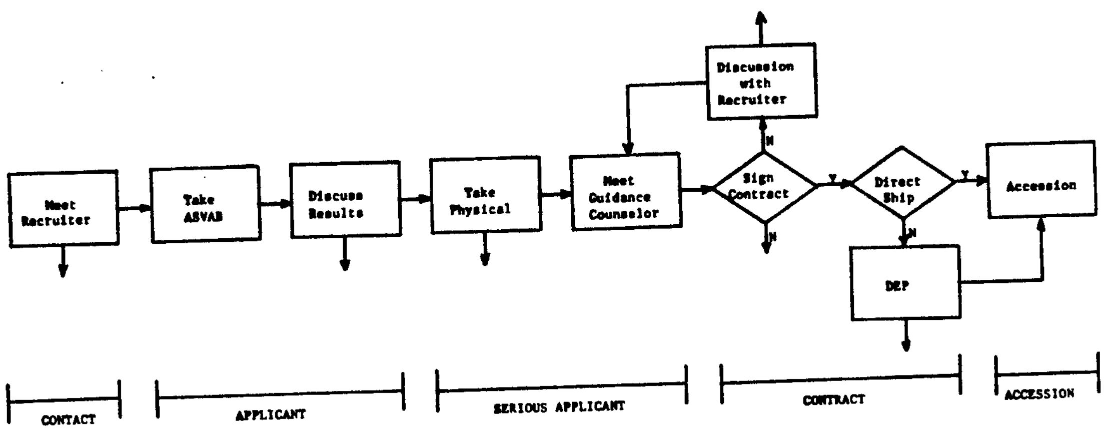
The Enlistment Process. In order to accurately project candidates for enlistment it is necessary to understand the workings of the system. Figure 1 provides a general model of the process. It begins with a candidate arranging a meeting with a recruiter at a local recruiting station. Here the recruiter makes initial contact with a potential applicant and becomes responsible for that person's entry to the system. It is the recruiter's duty to 'sell' the Army, but not a particular MOS, to a potential candidate. At the same time the recruiter makes the initial determination of whether a person is desired by the Army. One of the tools currently employed in making this determination is the Computerized Adaptive Screening Test (CAST). Part of the JOIN system currently being implemented at recruiting stations and MEPS across the country, this fifteen question test was designed to predict a person's ASVAB score. It measures basic verbal skills (word associations, completing sentences) and arithmetic skills (basic multiplication, division, percentages, etc.). The CAST is required for all non-high school graduates but is also being used to screen other candidates. A person will be defined a 'prospect' at this point.

Once a potential applicant has passed this point, he or she is scheduled to take the ASVAB (if not already taken). This usually occurs within a few days of initial contact. After the taking of the ASVAB, a person will be considered an 'applicant' for the purposes of this paper. When the ASVAB score is received by the recruiter, a meeting with the applicant is arranged to further discuss options available in the Army. (Since formal records are not kept at the aggregate level, it is impossible to measure the number of individuals lost prior to this point.)

The next stage of the process involves a trip to the Military Entrance Processing Station (MEPS). It is at one of these regional centers that the final steps in the applicant-contract process take place for all Armed Services. A physical examination is first taken. During FY81-FY83, approximately 25-30% of

FIGURE 1

THE U.S. ARMY ENLISTMENT PROCESS



the total number of AFQT Cat I-IIIA male NPS HSG applicants were lost between application and the taking of a physical. (Once having taken the physical, the applicant will be defined a "serious applicant"). The next (and final) step in the process is a meeting with a guidance counselor. It is here that the actual person-to-MOS match occurs. The serious applicant is given a list of alternatives matching current needs of the Army to the person's minimum qualifications. At the point of signing an Army contract, an individual will be considered a "contract". The loss rate at this point for male NPS I-IIIA HSG during FY81-83 ranged from 7 to 21%. The contract must now decide whether to enter the Delayed Entry Program (DEP) or access immediately. The DEP allows an enlistee a delay of up to one year before accessing. It also gives an individual the flexibility to select an MOS that may be currently closed but available at a later date. The length of DEP permitted depends on Army policy as well as available training slots and personal preferences. While average time in DEP is only a few months, high school seniors are permitted to remain in the DEP for up to one year. (A sizable number of persons are lost while in the DEP. Averaging 4-7 percent, the number has been rising in recent years.) Once leaving the DEP, a person becomes an "accession".

Recruiter Missions. Army manpower goals play a crucial role in determining who will eventually sign Army contracts. These manpower goals are ultimately determined by the current needs of the Army. While the total end strength is mandated by Congress, the Army is given leeway in determining the structure of the force. The Office of the Deputy Chief of Staff for Operations and Plans (ODCSOPS) determines the optimal structure to assure the accomplishment of the Army's objectives. The Active Army Military Manpower Program (AAMMP) produced by ELIM-COMPLIP then specifies accession goals for up to five years into the future. (McWhite, et. al., 1983) This information provides the US Army Recruiting Command (USAREC) with goals for recruiting (inflated to account for loss from the DEP). USAREC initially allocates missioning goals among the nation's five Recruiting Brigades. From there, they are distributed to the 56 Army Recruiting Batallions, further allocated to the over 250 Recruiting Companies, and are finally transformed into individual recruiter 'missions' at the 2,200 Recruiting Stations across the nation. While aggregate missions are allocated by reception station month at the beginning of the fiscal year, adjustments are made periodically.

Recruiters are given 'mission boxes' to fill, each box representing a category of individual. Non-prior service males in AFQT categories I-IIIA are divided into three mission boxes: high school graduates, high school seniors, and non-high school graduates. AFQT category IIIB individuals are treated similarly, as are those in AFQT category IV. Those with prior military experience fill the final mission box and are treated as a single unit. Recent data indicates that mission box contents for the most desired individuals (AFQT category I-IIIA male NPS HSG) are viewed as 'goals' while mission boxes for the least desired individuals are viewed more as 'limits'. Mission box contents at the recruiter level are based upon past performance of the recruiter and Recruiting Company as well as the overall goals of the Army. Recruiters are currently assigned missions by 'reception station month'. Recruiters are also given goals for 'recruiting weeks', requiring them to make a given number of contacts during the week. These goals are more informal, however, and may differ from Company to Company.

Factors Influencing Enlistments. Many variables have been shown to influence the enlistment of an individual in the Army. Included are both Army (or policy) driven variables and externally generated factors. Perelman (1983) decomposed these

variables into four broad categories: micro-sociodemographic variables, taste variables, program policy variables, and econodemographic variables. Micro-sociodemographic variables include such personal characteristics as age, gender, and AFQT score. Taste variables include factors such as propensity to enlist. Program policy variables involve a broad range of factors including (but not limited to) the number of recruiters, recruiter productivity (quotas), military pay, bonuses, advertising, tour length, and interservice competition. Since many of these policy variables are subject to readjustment and may be highly correlated, they present problems when developing a forecasting model. The fourth category of variables, econodemographic variables, includes unemployment rates and the supply of those eligible for enlistment. Since this paper is concerned with forecasting only specific categories of individuals, the micro-sociodemographic variables will be treated as the dependent variable to be forecast, and the program policy and econodemographic variables will be considered explanatory variables. Taste variables are not used in the analysis.

Recruiters can influence the arrival of individuals within the system. For example, a recruiter could discourage a person from applying because he may not feel that the individual would meet the mental or physical requirements of the Army. This individual would never show up as an applicant. Recruiter behavior may also be shaped by mission boxes. Because recruiters are rated on the basis of how well they fill their missions, such an action as delaying an individual from applying during a particular month because the recruiter's mission box for that type of individual has already been filled, is possible. The extent of this type of recruiter behavior is virtually impossible to measure.

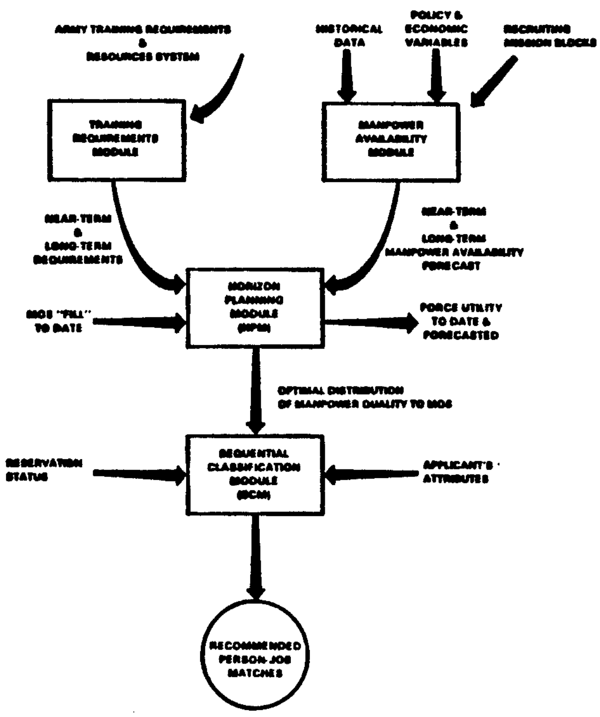
Army training policies can influence both the arrival pattern of individuals and their probabilities of signing contracts. A person may not sign a contract until he or she knows that a particular training seat is available, causing the timing of training classes to influence contract signing. This could cause more high quality applicants to sign contracts when the most attractive MOS are available. In this case time series might not reflect the arrival pattern for that type of individual.

Changing DEP policies are also an important influencing factor. These policies change frequently and influence when a person signs an Army contract. Current research (WESTAT, 1984) has shown that longer DEP periods are correlated with higher DEP loss rates. Specific MOS are periodically closed to particular individuals to assure the desired quality mix within that MOS. Other endogenous factors influencing the arrival of applicants or the signing of contracts include advertising, college bonus programs, enlistment bonuses, and the number or quality of recruiters. All of these factors must be remembered when interpreting time series data.

Unemployment has been seen to be a factor influencing Army enlistments. As unemployment rises in the civilian sector, military service becomes a more attractive alternative. Several forecasting models have used unemployment as one of the major independent variables affecting the enlistment of NPS I-IIIA male HSG. Dale and Gilroy (1983) used current teenage male unemployment as well as unemployment lagged two and four months as independent variables in their regression model to forecast Army contracts. Fernandez (1979) used differing youth unemployment scenarios to forecast the long term enlisted supply through 1990.

The Enlisted Personnel Allocation System. To optimally allocate Army enlisted personnel, the Army Research Institute is developing an Enlisted Personnel Allocation System (EPAS). Figure 2 provides a schematic of the system construct. EPAS is comprised of four separate modules: a training requirements module, a manpower availability module, a horizon planning module (HPM), and a sequential classification module (SCM). The training requirements module accounts for training requirements of different MOS over time. The manpower availability module (or supply module) will forecast the numbers and types of individuals likely to be available for enlistment during particular time periods. The HPM will aggregate the requirement and availability data and derive an optimal set of allocation goals. The SCM will determine what specific MOS will be offered to an individual.

FIGURE 2
ENLISTED PERSONNEL
ALLOCATION SYSTEM



EPAS should improve the Army's enlisted personnel allocation procedures by allocating individuals to achieve higher performance, reduce training costs and lower attrition while maintaining a high class fill rate and assuring adequate enlistment rates. EPAS will also greatly enhance the capabilities of decision makers to investigate the impact of policy alternatives prior to implementation.

This paper will focus upon the manpower availability module. The availability module will provide both short and long-term forecasts. Long-term forecasts will project the impact of policies (such as goals and other recruiting incentives) and exogenous factors (the economy, relative pay, etc.) over periods of one year or more. The short-term forecasts will project the number of individuals likely to enter the recruiting system within the next month or two given specific policies and recent trends.

IV. SHORT TERM FORECASTING

An assortment of quantitative techniques are currently available for generating short-term forecasts (For the purposes of this paper, "short term" will refer to one to several periods into the future). Quantitative forecasting techniques can be broken into two broad categories: causal models and time series models. Causal models can take on different functional forms, forecasting a dependent variable as a function of several explanatory variables. Sufficient information concerning the system to be forecast is necessary. Causal models include regression and econometric models.

Time series models use past behavior of a system to predict future behavior of the same system. Time series models perform best with stable data and are used mostly for shorter term forecasts than are causal models. They are usually composed of four components: a trend, cyclical, seasonal, and random component. Included are exponential smoothing, autoregressive models, moving averages, and Box-Jenkins (ARIMA).

Several factors influence the selection of a forecasting method including forecast period and lead time. Exponential smoothing may only be accurate to one or two periods ahead. Methods such as ARIMA (utilizing autocorrelation) can make more accurate forecasts several periods out. The stability of the process can also influence model selection. If the process appears to be simply random variation about a constant mean, a smoothing method may be sufficiently accurate.

Several studies have rated the relative merits of different short-term forecasting techniques. Makridakis et. al. (1982) conducted a forecasting competition comparing 22 different time series techniques. In this study, forecasts were provided for multiple horizons using up to 1001 series of data. For one month forecasts, several versions of exponential smoothing showed highest average ranking. They also ranked highly in term of mean average percent error (MAPE) when using yearly, seasonal, and monthly data. The results of this competition infer that the sophisticated methods did not do significantly better in generating one period forecasts than the simpler exponential smoothing methods.

A study completed by James Carrig (1983) tested the same methods along with an additional method, the Adaptive Learning Network (ALN). Although much more complex than the exponential smoothing models in structure, the ALN was observed to be only slightly more accurate in terms of MAPE.

V. RESULTS

To select an appropriate method for forecasting the number of "high quality" applicants to sign Army contracts in the near term, it is necessary to understand patterns that exist within the process. This understanding can provide valuable information concerning appropriate forecasting methodologies to be used as well as forecast period and horizon. For the purposes of this paper, the term "high quality" will refer to AFQT category I-IIIA HSG and HSSR.

Weekly and monthly applicant and contract time series for the fiscal years 1981-83 were derived using MEPCOM monthly edit tapes (The fiscal year runs from October 1 - September 30). Only non-prior service (NPS) male HSG in AFQT categories I-IIIA were examined (HSSR will be considered together with HSG). For this part of the analysis, the categories were further broken into four "supply groups"; AFQT category I-II whites, category I-II non-whites, category IIIA whites, and category IIIA non whites. AFQT category I-II whites were by far the largest group, making up approximately 59 percent of the total number of contracts examined over the three year period. The other three groups contributed only 6, 28, and 7 percent of the total, respectively. As previously discussed, these supply groups are considered to be those most desirable as Army accessions. They not only qualify for most MOS but also exhibit lower attrition rates (and therefore lower training costs per person) than non-high school graduates and persons in lower AFQT categories (Manganaris, 1984). (Those persons with prior military experience were not included because they have different training requirements than non-prior service accessions and also compose a relatively small percentage of the total number of applicants. Women were not included in the analysis because they make up a relatively small percentage of the total force and their choice of accesion MOS is limited.) Analysis was limited to weekly and monthly data. In this paper, the term "month" will refer to reception station month and "week" will correspond to recruiting week. (A reception station month roughly resembles a

FIGURE 3

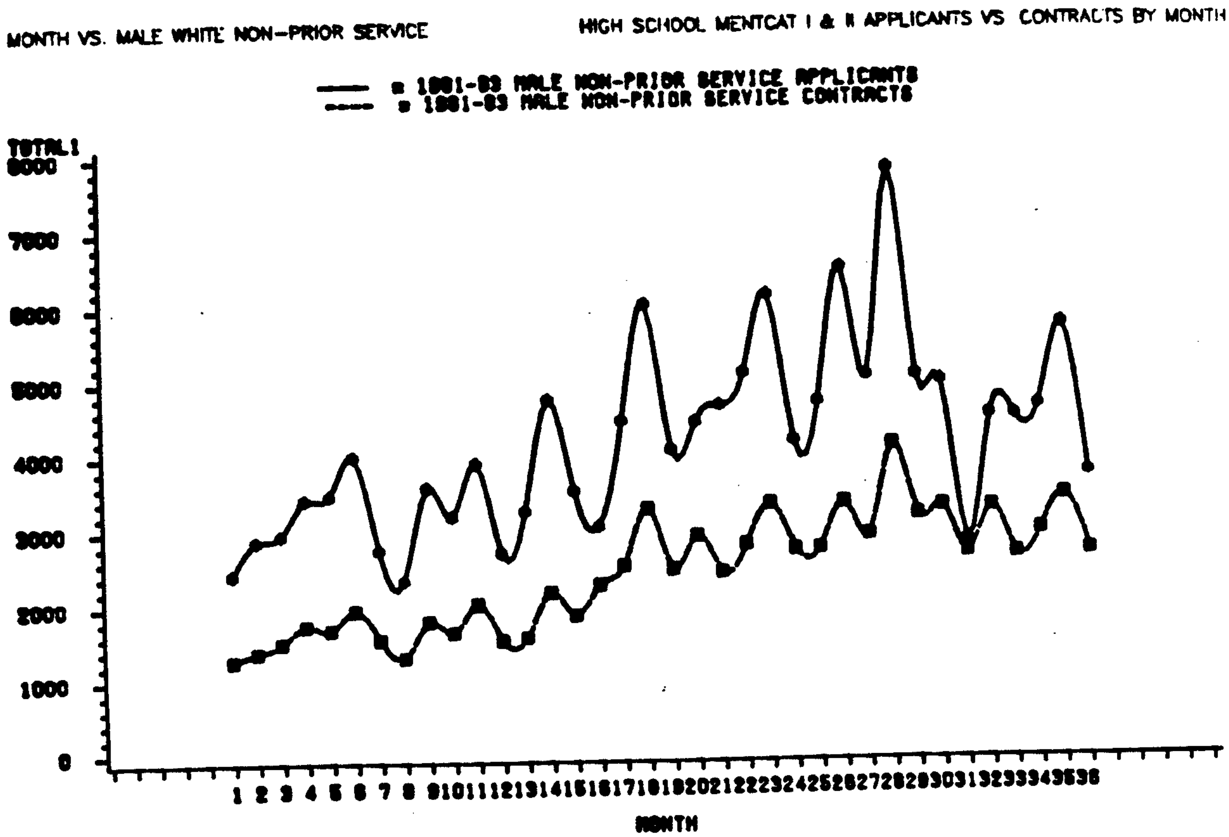


FIGURE 4

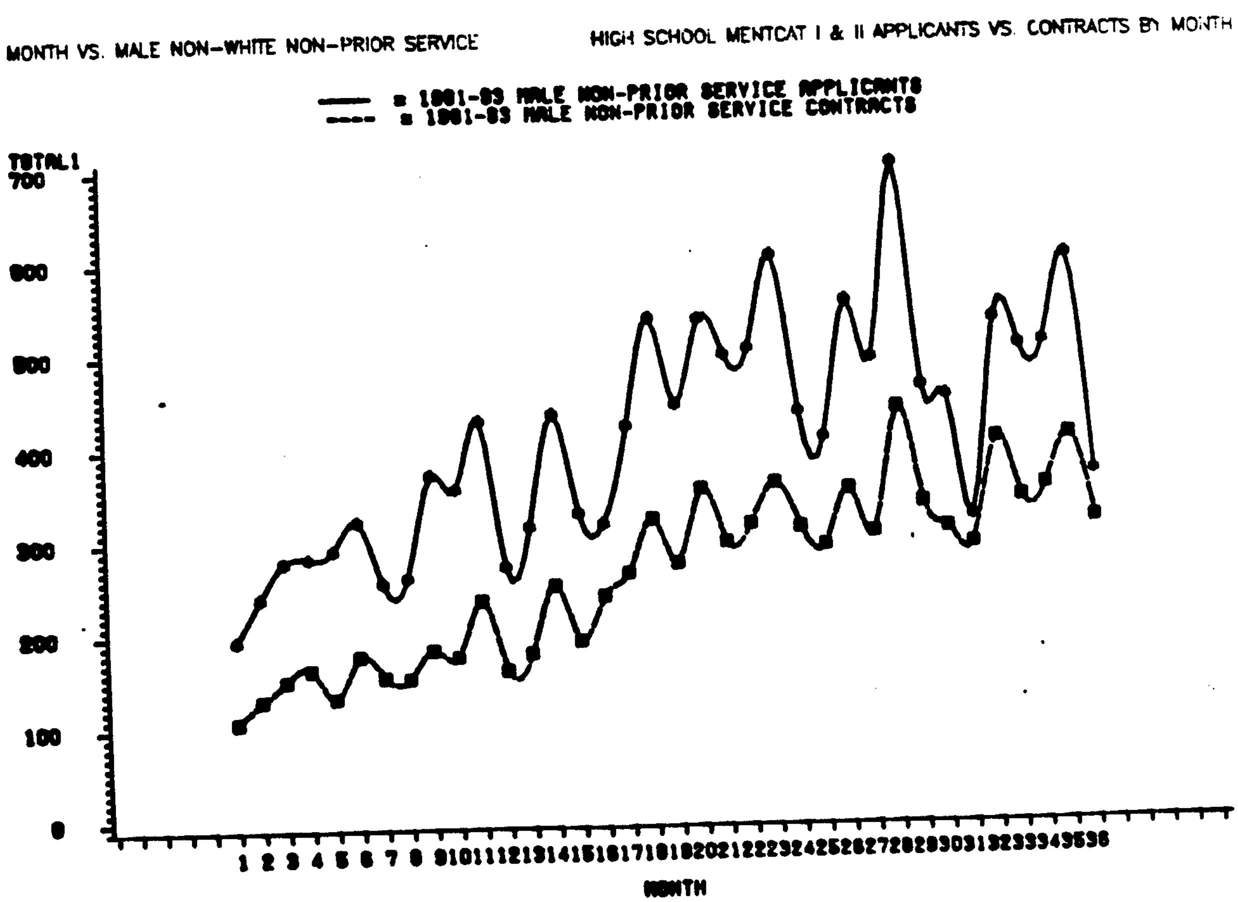


FIGURE 5

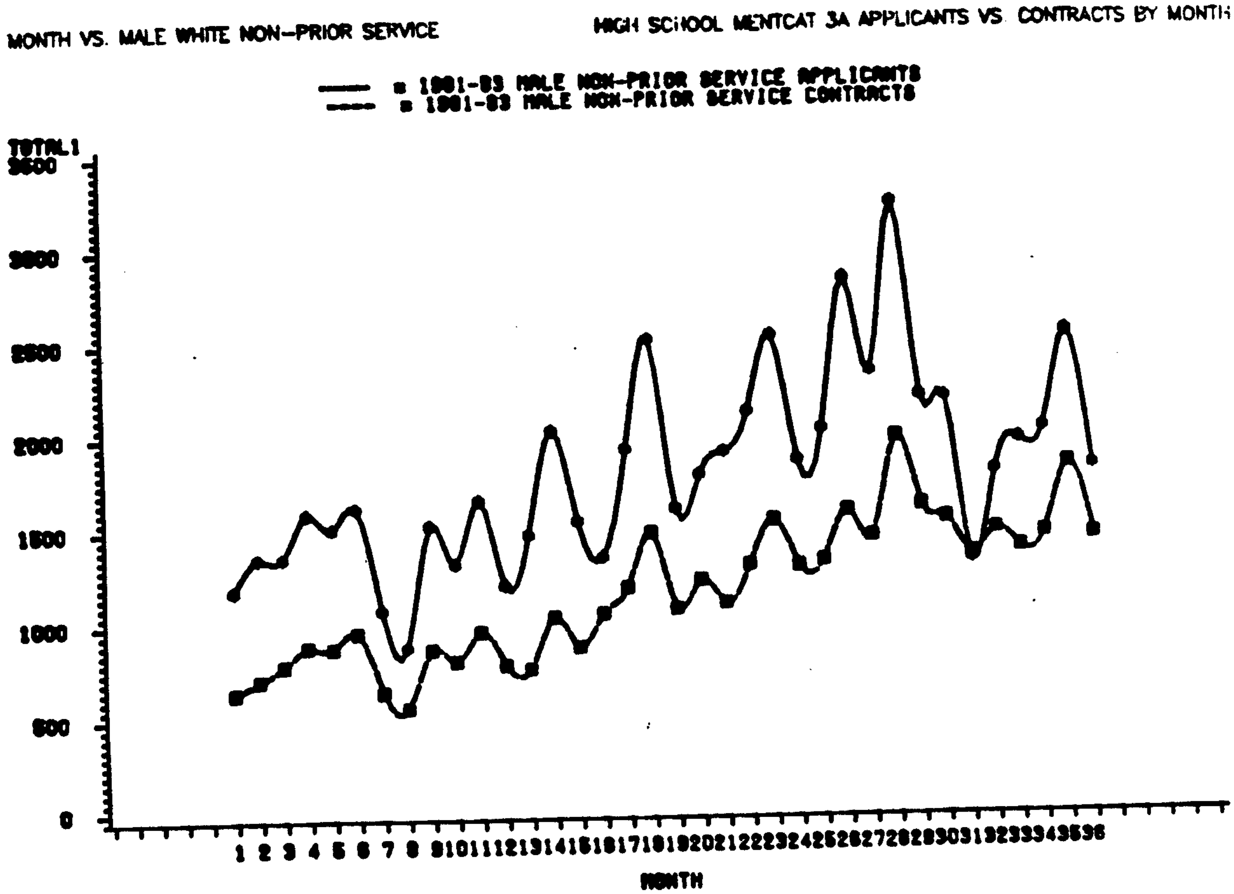
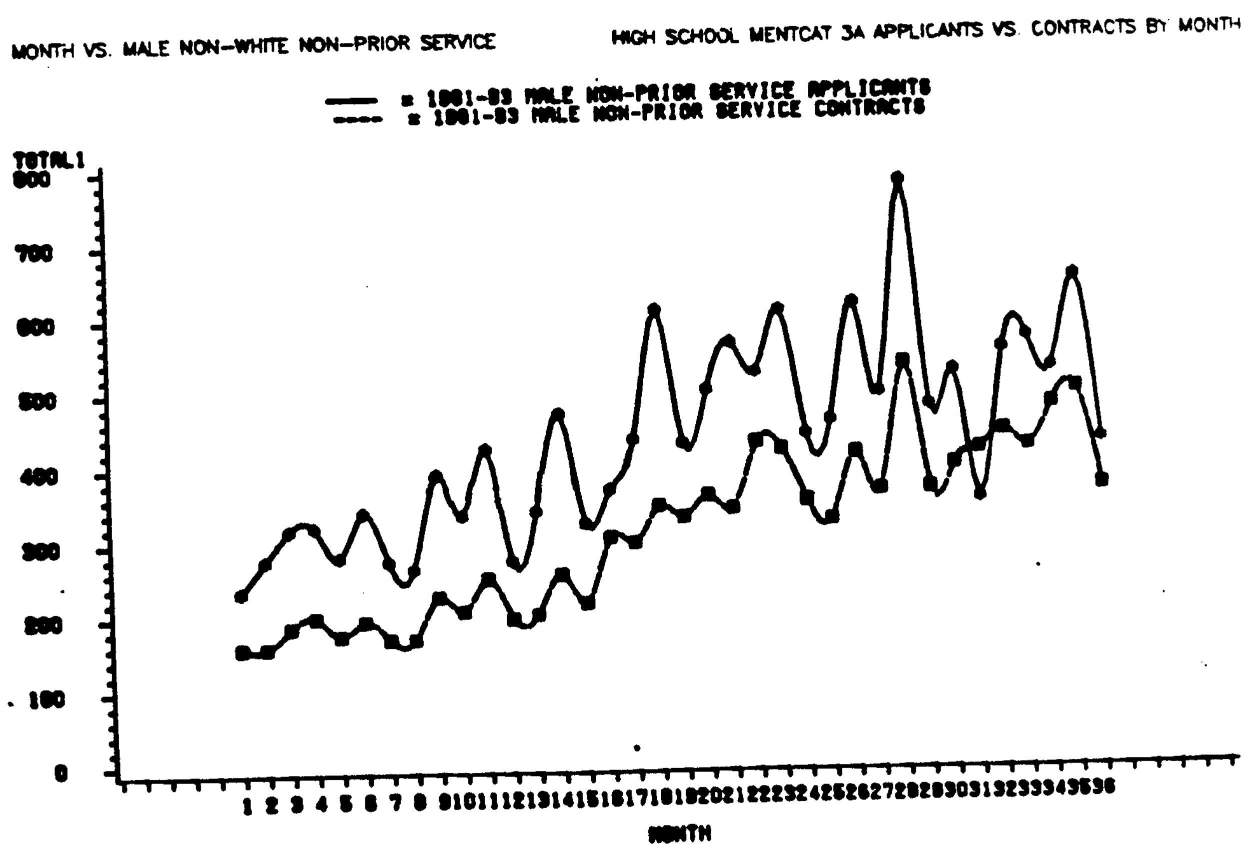


FIGURE 6



calendar month. However, a reception station month always begins on the first Tuesday of the calendar month and ends the last Monday of the calendar month, resulting in each month having exactly four or five weeks. A recruiting week also runs Tuesday-Monday). In this way, a comparison to recruiting policy is possible.

By aggregating the data on a weekly basis, it is possible to examine the distribution of contracts within months. This will assist with the determination of whether predictable patterns can be discerned occuring within all months, between only specific months, or exist at all. Week-to-week variation may also be particularly predictable during holiday seasons, a time when dropoffs have historically occured. Analysis of weekly data was limited to examination of these holiday effects along with contract distribution within months (These results are included in the Appendix).

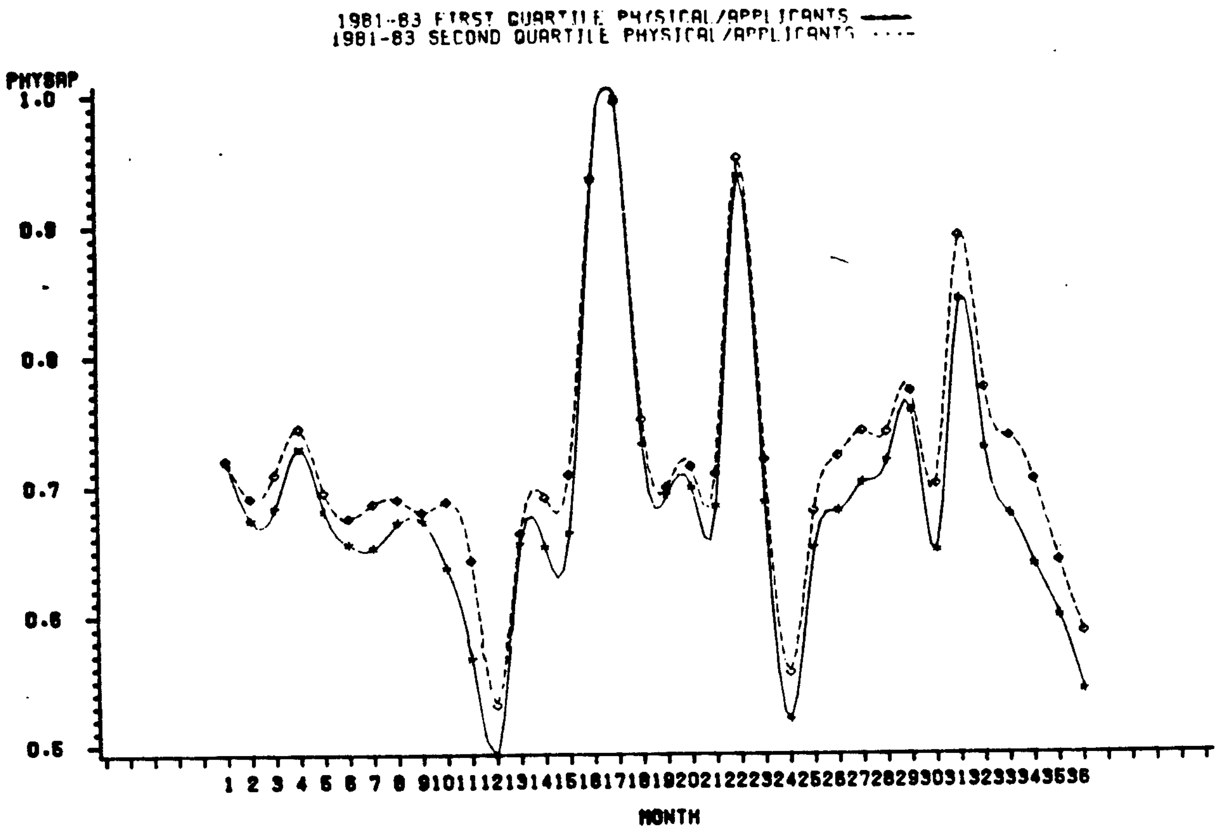
Monthly data is used for the majority of the analysis. This permits a comparison of contracts signed to Army goals. Trends over the three year period may also be more noticeable because monthly aggregation can absorb much of the random week-to-week variation as well as slight or short lasting holiday effects, while capturing longer lasting seasonal effects.

Monthly applicant and contract time series for the four supply groups can be seen on Figures 3 to 6. These figures give an indication of recruiting trends during the three year period. During FY81 (months 1-12) contracts signed in the examined categories remained fairly stable for the majority, with a visible decline of both applicants and contracts for April and May 1981 (months 7-8). While the level remained relatively constant for whites, an upward trend is apparent for non-white applicants and contracts.

An obvious change can be seen during FY82. All four supply groups experienced an accelerated upward trend lasting throughout the year. This applicant trend slackened during December and January but again picked up in February and continued until September. The monthly increase in contracts actually outpaced the rise in applicants during the year. (The September decline may be due to early filling of Army missions and not a drop in potential candidates.)

FIGURE 7

MONTH VS. FIRST AND SECOND QUARTILE PHYSICAL/APPLICANT RATIOS



result of explicit policies, such as meeting end strength targets. It can be estimated that an average of 65 percent of all male NPS HSG category I-IIIA applicants proceed to the point of taking a physical.

An important question to answer is, once a person with given characteristics applies to the Army, what is the likelihood that this person will sign a contract? While on an individual basis this is a personal decision involving many variables, in the aggregate some generalizations can be made. Two conversion ratios were calculated to examine this question. These were the ratios of contract signers to total applicants and contract signers to serious applicants. Again, these were calculated monthly for the upper two quartiles. The results can be seen on Figure 8.

During FY83 the pattern again changed. The first several months continued the upward trend of the previous year. However, this trend peaked during January 1983. In the subsequent three months all supply groups experienced a sharp decline in applicants (as much as 50 percent). Some recovery was seen during the last five months of the year, particularly among non-whites. The white applicant totals did not match those of several months previous, however. Due to the high number of applicants during the beginning of the fiscal year and relatively high number of non-whites, all four supply groups experienced net increases in both applicants and contracts over FY82. The contract totals again did not precisely follow the applicant patterns for the year.

The appropriate point in the applicant to contract process to be forecast must be determined. As previously noted, the process takes place in several steps. There are lags associated with each point in the process and the applicant may drop out at any time. Due to the nature of the process, short-term forecasts made at different points could yield different results.

There are specific advantages involved with forecasting applicants. The arrival of applicants may most closely represent the short-term supply of individuals to the Army. It enables early identification of any problems affecting the short term signing of contracts. Applicant forecasts could also be used as a policy tool whereby the conversion ratio necessary to meet short-term goals could be determined. By taking into account lag time between applicant and contract, the number of contracts to be signed in the coming month could also be estimated.

The forecasting of applicants is not without its drawbacks, however. Because contracts (and ultimately, accessions) must be forecast at some point, applicant projections must lead to contract forecasts. Contract forecasts can only be calculated indirectly when using applicant forecasts. To accurately derive contracts from applicants it becomes necessary to use estimates for lag times and conversion ratios, each of which has an associated error. The flow of applicants is also more variable than for contracts, and is more influenced by random variation.

The forecasting of contracts directly may be desirable because it eliminates the estimation of several parameters and some of the random noise associated with applicant forecasts is removed. However, the number of contracts may be highly influenced by Army goals. Army policies play a large part in the determination of who will sign an Army contract. Also, some of the forewarning capability of the applicant projections would be lost, with potential problems not being indicated until later.

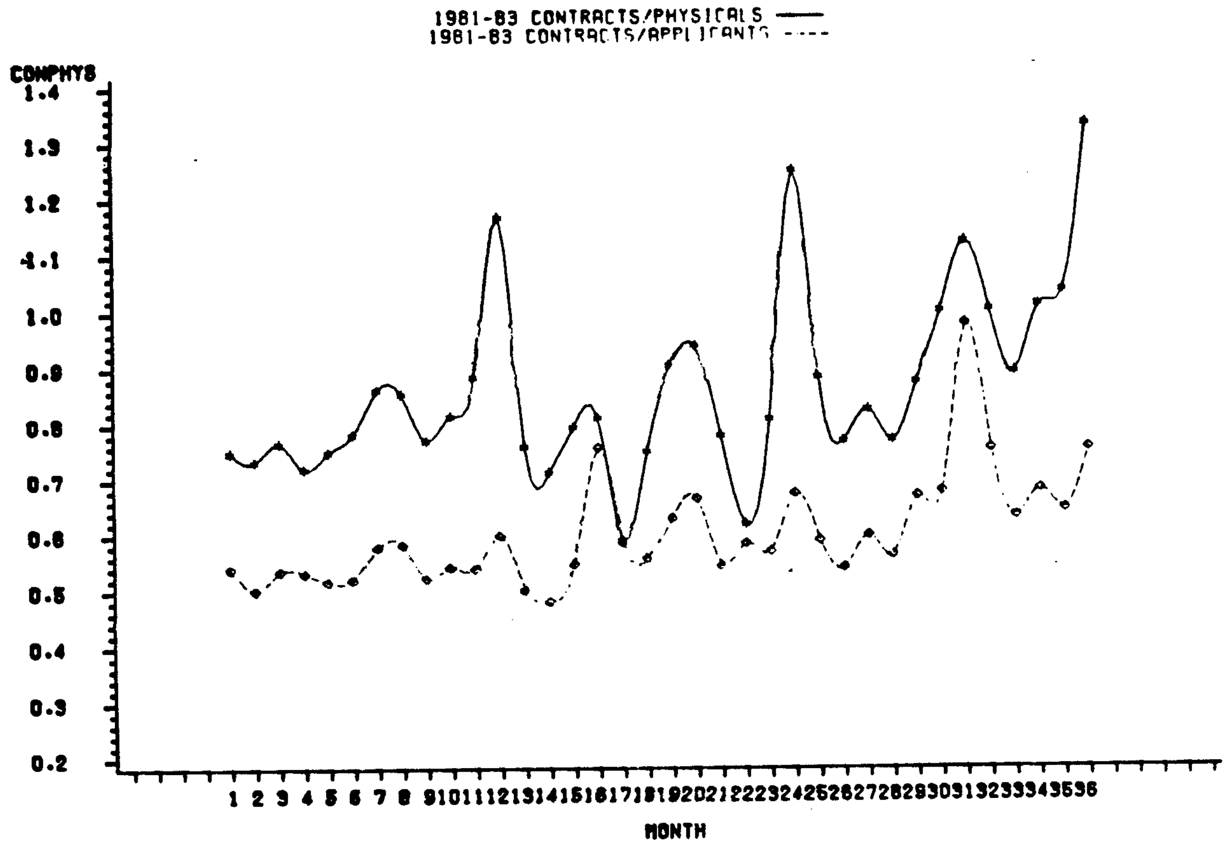
A third alternative is to forecast serious applicants. By forecasting serious applicants much of the random variation caused by applicants who were not really interested may be eliminated, while still representing the true arrival pattern of applicants. At this point, a person is much closer to the signing of a contract. Also, this information may be particularly useful in determining the optimal(or desired) capture rate.

A large proportion of Army applicants are lost between the time the ASVAB is taken (and a person by definition becomes an applicant) and the time the physical is taken at the MEPS. The monthly serious applicant/applicant ratio will be used as a rough estimate of the probability of becoming a serious applicant. (Due to the lag between becoming an applicant and then a serious applicant, the observed populations are slightly different and therefore rates obtained are only rough estimates.)

Results of the monthly serious applicant/applicant ratio plots can be seen in time series form on Figure 7. For this analysis, supply groups were broken into quartiles rather than AFQT categories in order to be consistent with other EPAS research (Moore, 1983). (Quartile 1 refers to those scoring 75-99 on the ASVAB and quartile 2 refers to those scoring from 50-74.) Upon examination of the data, there are several observations worth noting. The two quartiles exhibit remarkably similar patterns during the three year period, with the rates for second quartile individuals remaining slightly higher throughout. Both quartiles experienced slightly higher average monthly ratios during FY82 (.738 and .758 for quartiles 1 and 2, respectively) than in either FY81 (.653 and .679) or FY83 (.683 and .724). Each fiscal year also ended at a relative low point in September. This is likely the

FIGURE 8

MONTH VS. TOTAL CONTRACT-APPLICANT RATIOS



The contract/applicant ratios exhibited an upward trend throughout the period, indicating that a higher percentage of applicants have been completing the process. The two quartiles followed similar patterns throughout, with those in quartile 2 experiencing slightly higher contract signing rates. These estimates ranged from .51 and .57 for quartiles 1 and 2 in FY81 to .62 and .72 for the two quartiles in FY83. While the proportion of applicants taking physicals dropped to relative lows each September, the contract/applicant ratios experienced relative highs. Again, this seems to be policy influenced.

The contract/serious applicant ratios experienced similar results throughout the period. An upward trend is again apparent, and during several months the ratio actually exceeded 1. During those months more people signed Army contracts than actually applied and took physicals. Several explanations for this are possible. Since a lag may occur between taking a physical and signing a contract, these activities can overlap across months. In this case we may be dealing with slightly different populations. Also, some of those who applied earlier but did not sign contracts may have been actively sought again to fill monthly quotas. The average monthly ratios for the upper quartile were .79, .77, and .92 for FY81-83. The ratios were slightly higher for the second quartile (.85, .84, and .99). This indicates a high probability of signing a contract once an applicant has taken the physical.

The actual time elapsed between application to the Army and the signing of a contract has been shown to be relatively short. [Schmitz and Nelson (1984) found that for FY81 the median time from applicant to contract was only eight days.] The distribution of times from applicant to contract for the two upper quartiles can be seen on Tables 1 and 2. These tables show the changing nature of the applicant to contract process during this period. While a relatively large percentage of applicants signed a contract within one week of application, the time lags have been getting longer. The upper quartile experienced a decrease from 43 percent to 30 percent in the number of contracts signed within the first week. The number for the second quartile dropped from 48 to 35 percent during the same period. (Due to the overlapping of applicants between years, however, these results are slightly biased.) This may be due to the increased number of individuals from these categories entering the system or a combination of several other factors. Another observation from these tables is that those in the upper quartile consistently took longer to complete the process than individuals in the second quartile.

TABLE 1

Applicant to Contract Lag Time, Upper Quartile
(Rounded to Nearest percent)

	FY81	FY82	FY83
Within 1 week	43	35	30
1 - 2 weeks	17	19	19
2 - 3 weeks	8	10	10
3 - 4 weeks	5	5	6
4 - 5 weeks	17	19	22
5 weeks - 1 yr	10	11	13

TABLE 2

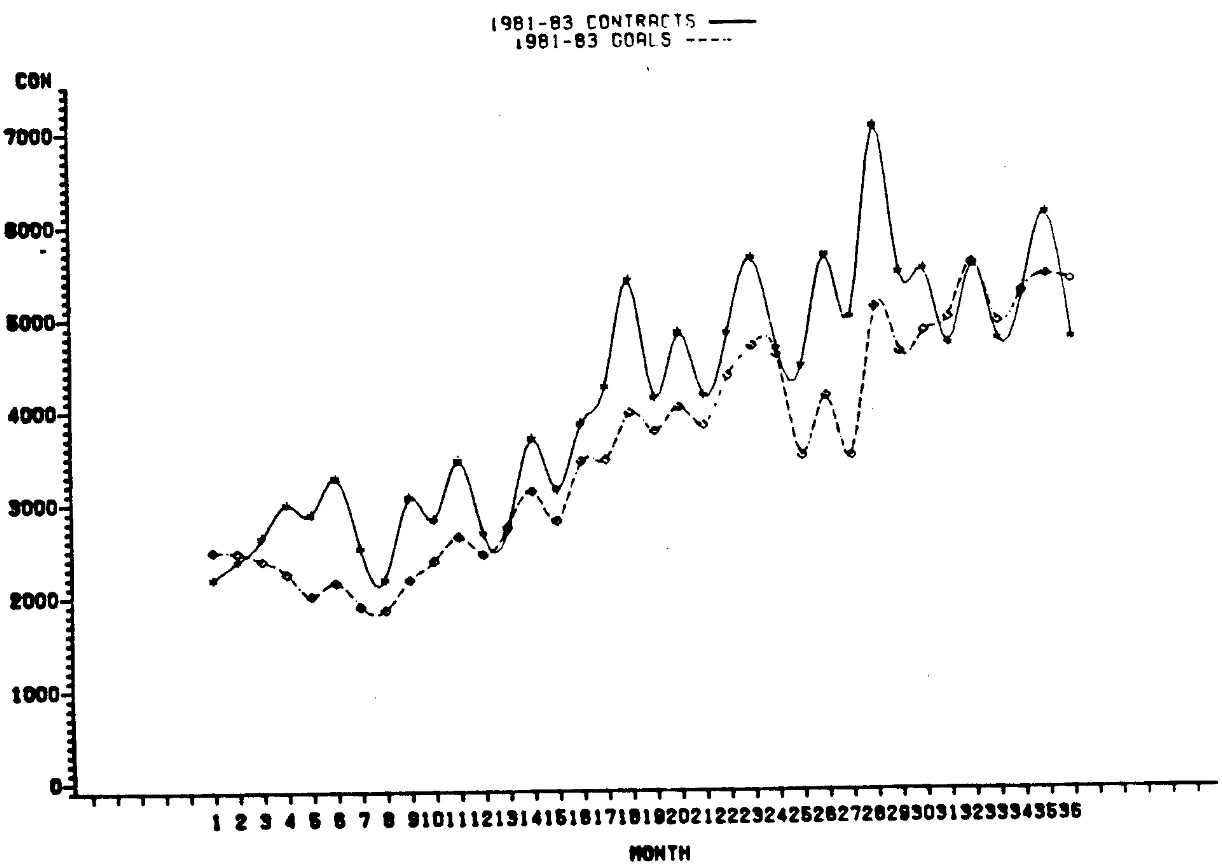
Applicant to Contract Lag Time, Second Quartile
(Rounded to nearest percent)

	FY81	FY82	FY83
Within 1 week	48	40	35
1 - 2 weeks	16	19	18
2 - 3 weeks	8	9	9
3 - 4 weeks	4	5	6
4 - 5 weeks	15	17	20
5 weeks - 1 yr	9	10	13

Recruiter goals are seen to influence the number of high quality individuals to sign contracts. Figure 9 shows monthly contracts signed for AFQT category I-IIIA non-prior service male HSG and HSSR versus goals for these categories during FY81-FY83. A correlation of .9 was found between goals and contracts during this period. As is clearly visible, over most of this period the Army had little difficulty in meeting aggregate goals for these supply groups. In FY81, monthly missions for these individuals remained at similar levels (approximately 2500) at the beginning and end of the year, with lower missions during the middle of the year. Monthly missions rose throughout FY82, with an increase for AFQT category I-IIIA male NPS HSG from approximately 2,700 in October to over 4,500 towards the end of the fiscal year. This is the result of the Army's effort to increase the percentage of high quality personnel.

FIGURE 9

MONTH VS. TOTAL CONTRACTS AND GOALS



One factor which may influence the usefulness of the FY81 monthly missions for forecasting is that recruiter mission boxes were filled on a quarterly, not monthly, basis. The official policy of assigning monthly missions was not implemented until FY82.

While the upward trend in missions continued during FY83, the number of contracts did not match this increase. By the end of the fiscal year the Army began to fall short in these categories.

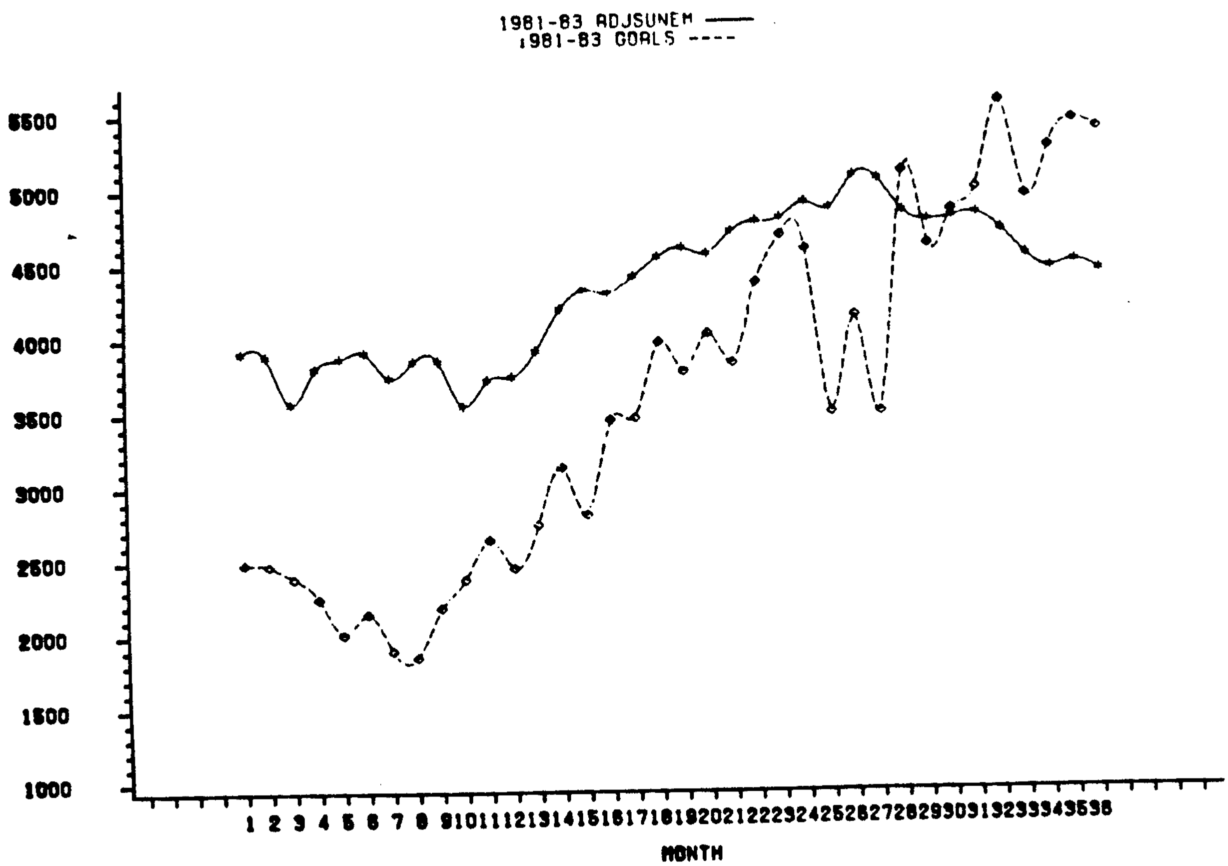
The period examined (FY81-83) was a time experiencing relatively high civilian unemployment rates. It was decided to examine 16-21 male unemployment rates, since this is the population from which most of the individuals recruited for military service are drawn. During this period, unemployment rates for these individuals varied from almost 15 percent to over 25 percent. While the rates dropped each summer, seasonally adjusted rates indicate a relatively constant rate throughout FY81 (unadjusted rates of 15-20 percent), a rise during FY82 (to 23 percent), peaking during the early FY83 (25.5 percent in February 1983) and followed by a decline during the remainder of the fiscal year. (This decrease has continued through the beginning of FY84). This is consistent with the pattern of NPS I-IIIA male HSG serious applicants during the same period.

During the three years applicants, serious applicants, contracts, and goals were found to be highly correlated with seasonally adjusted unemployment rates. The highest correlation was between seasonally adjusted unemployment rates and NPS I-IIIA male HSG contracts (.85). This observation is not surprising since unemployment at least indirectly influences the supply of applicants. [Dale and Gilroy (1983) found unemployment to be an important factor in their model to forecast contracts.] Other correlations with seasonally adjusted unemployment rates were goals (.8), serious applicants (.71), and applicants (.72). Again, the number of contracts were greatly influenced by goals in what had essentially been a goal driven system. A comparison of goals for NPS I-IIIA male HSG to seasonally adjusted 16-21 male unemployment can be seen on Figure 10. (Keep in mind that goals are aggregated by reception station month and unemployment by calendar month, so results may be slightly out of agreement. More consistent data could result in higher correlations.)

Given the fact that Army goals have so greatly influenced the contracting of male NPS I-IIIA HSG and HSSR during the past several years, it becomes necessary to forecast contracts rather than applicants or serious applicants in the short-term. While serious applicants may more closely represent the labor pool currently available to the Army (and therefore attractive to forecast), conversion rates from serious applicants to contracts as well as the number of contracts have been shown to be largely the result of current Army missions. Therefore, when forecasting male NPS I-IIIA HSG in the short-term, recruiter missions must be included. This necessitates the forecasting of contracts. Since recruiter missions are allocated by reception station month, this was selected as the forecast period.

FIGURE 10

MONTH VS. GOALS AND SEASONALLY ADJUSTED UNEMPLOYMENT



Unemployment not only influences the formulation of Army goals, but also determines who will be in the available labor pool. Male 16-21 seasonally adjusted unemployment lagged one month was found to be closely correlated with monthly contracts and goals during the three year period. This is appealing since it roughly corresponds to the lag associated with the time between applicant and contract.

Past recruiting success can also help explain what will happen during the current period. To measure past performance, the goal achievement rate was calculated. (This rate is defined as the ratio of contracts signed to recruiter mission). This variable (lagged one month) was used to interact with lagged seasonally adjusted male 16-21 unemployment, creating a new variable.

Time series methods were found to produce unsatisfactory results when run against the FY81-83 contract data. Exponential smoothing also proved unresponsive when dealing with monthly variation. The lagging effect made single period forecasts innacurate. With much of the variation caused by such exogenous factors as changing goals and unemployment rates, both an autoregressive model and ARIMA were found to be inappropriate. (These methods may become more useful, however, if the supply becomes constrained.) For this reason, a causal model was chosen.

The forecasting model was developed using FY81-83 contract data. The explanatory variables used included recruiter goals for male NPS AFQT I-IIIA HSG and HSSR along with the term accounting for the interaction between recruiting success and unemployment. Ordinary least squares (OLS) was used to fit the model. The model explained most of the variation during FY81-83 (R-square=.87), yielding an average percent error (APE) of 9.49 percent during this period. The model can be expressed as:

$$C(t)=.86568 + 80.137\ G(t) - 853.13554\ A(t-1)$$

Where:

$C(t)$= Contracts signed during period t

$G(t)$= Contract goal for period t

$A(t-1)$= Goal achievement rate for previous period

$U(t-1)$= Seasonally adjusted male 16-21 unemployment rate for previous period

Model Validation. The model has performed well in explainning the historical relationship between mission, the youth unemployment rate, previous mission accomplishment, and the number of contracts achieved. However, the value of the model is how well it will predict into the future, given the information available in the present. Therefore, we constructed an experiment to assess the usefulness of such a model under operational conditions.

The simulation was to make forecasts for the first few months of FY84 and compare them to both goals and actual contract achievement. Four months were chosen since this approximates the typical permitted DEP length. The decision being made from the forecast is what kind of MOS to allocate high quality individuals to, given the constraints of DEP policy. Thus, the allocation planning done today will have to compare expected supply with requirements over this period. Results of the four monthly forecasts as well as model fit can be seen in Figure 11.

Cumulative differences between forecasts and actual contracts are the measure of accuracy. The objective of the forecast is not the precise estimate of the arrival of each candidate, but the expected number within the allocation window determined by DEP policy.

Table 3 compares the actual contracts, recruiting missions, and model forecasts for the first four months of FY84. The contract missions provided reasonable estimates for planning purposes. The total error was 409 contracts or an underestimate of 2.1 percent of the actual contracts. However, the near-term model was within 0.4 percent, with an error of 77 contracts over the four month horizon.

Based upon this evidence, the near-term model should provide very accurate matching of personnel to MOS requirements. These projections will enable the allocation system of quality contracts. Furthermore, the self-correcting nature of factors such as contract goals and previous goal achievement should prevent the model from straying too far off the mark.

FIGURE 11

ONE MONTH FORECASTS

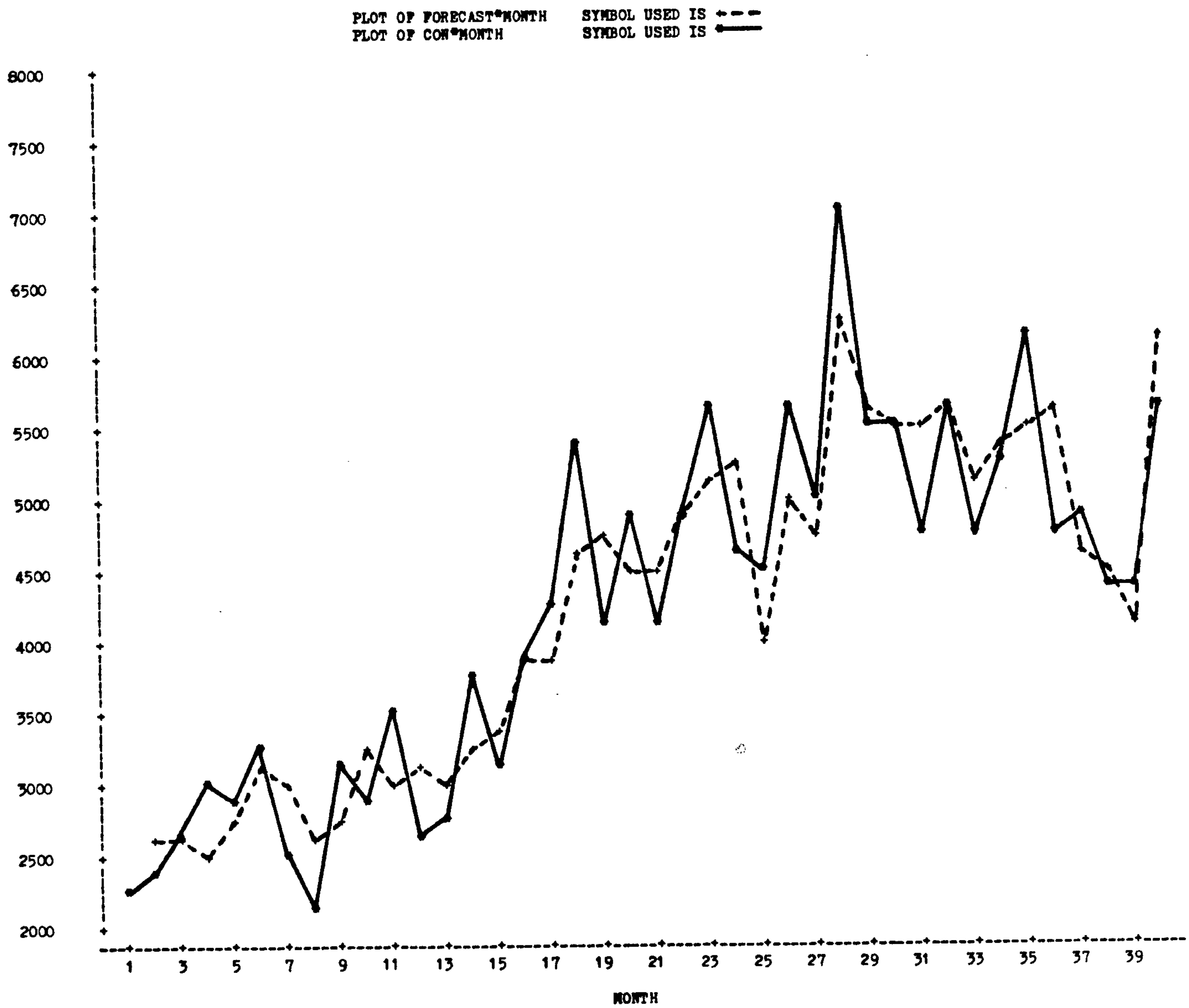


TABLE 3

COMPARISON OF FORECASTS FOR FY84

Month	Actual Contracts	Contract Missions	Goal Error	Model Forecast	Model Error
Oct 83	4,858	4,608	250	4,580	278
Nov 83	4,362	4,201	161	4,507	-145
Dec 83	4,394	3,903	491	4,115	279
Jan 84	5,610	6,103	-493	6,099	-489
TOTAL	19,224	18,815	409	19,301	-77

VIII. CONCLUSIONS

The applicant to contract process has been shown as consisting of several distinct steps (prospect, applicant, serious applicant, contract). Each of these steps has an associated loss rate. The process is usually completed in a relatively short time, with most completing the applicant-contract portion in a little over one week. (The serious applicant-contract segment is usually completed in a single day). Persons in the upper quartile were shown to consistently take slightly longer on average to complete the process. In each of the three years examined (FY81-83) all of those examined took longer to complete the process than in the previous year.

Unemployment plays a major part in determining who will be available to the Army in the short-term. Seasonally adjusted male 16-21 unemployment was found to be highly correlated with both Army goals and contracts.

Several trends were found to exist. There was an upward trend apparent throughout most of FY81-83 for high-quality applicants, serious applicants, and contracts. The most recent data indicates that this trend has leveled off and possibly reversed (This is also true for unemployment rates). Serious applicant to contract conversion rates rose and by the end of FY83 the system had very little

slack. When examined along with the increasing length of the process, this indicates that the system is reaching the point where immediate goals (unless lowered) will no longer be met.

While it could be attractive to forecast serious applicants in the short-term, the importance of recruiter missions necessitates the forecasting of contracts. Similarly, since recruiter missions are allocated by reception station month, this should be the forecast period. Total male NPS AFQT I-IIIA HSG and HSSR were found to be the necessary supply grouping. No other aggregation permitted a comparison to goals or goal achievements. The only other possible alternative structuring of supply groups would be to separate HSG from HSSR (While the Army does separate these groups into different mission boxes, the data available for this analysis only allowed for the aggregated grouping).

Time series models were not found to be accurate when used to model this ever-changing process. This is primarily due to the demand constrained situation that took place during FY81-83. If the supply of individuals becomes more constrained in the future, however, these methods could provide more accurate forecasts.

A causal model was found to generate accurate single period forecasts. This model, estimated with OLS, used recruiter goals, unemployment, and past goal achievement as the explanatory variables provided accurate forecasts when validated against the first four reception station months of FY84.

While accurate forecasts were made for the beginning of FY84, the model must be further tested. Periodic respecification may also be required to ensure accuracy. (It could be done on an annual basis, for example). This is especially true if the supply of male NPS cat I-IIIA HSG and HSSR again becomes supply constrained, as was the case prior to FY81.

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APPENDIX

WEEKLY TIME SERIES

Important information may be gained when examining applicants and contracts on a week to week basis. Weekly applicant and contract time series for the three year period are shown on Figures 1a to 8a. Each figure illustrates a different supply group.

To determine whether predictable patterns existed among contracts during the reception station month, the time series was broken into four versus five week months. Contract signing rates within months were then calculated. (Contract signing rates are defined as the ratio of persons signing a contract during a particular week within the month to the total number of contract signers during that month). These weekly arrival rates were averaged by year for four and five week months. The results are presented on Tables 1a and 2a (Each year contained eight four week months and four five week months). Upon plotting the four week arrival rates (Figure 9a), it is seen that all supply groups follow the same general pattern, with an increase during each successive week within the month for each of the three years. This pattern dampened somewhat both FY82 and FY83.

When examining five week months (Figure 10a) more differentiation is apparent between supply groups but again a pattern is seen; an average monthly rise throughout the first four weeks followed by a decline for the fifth week. This may be the result of Army policy, indicating recruiter's abilities to fill their mission boxes during the first four weeks (and not the arrival pattern of potential contracts). The patterns follow each other more closely during FY82 and FY83, after the monthly mission box policy went into effect. How the system influences who arrives and when is important and must be recognized when interpreting the time series results.

Some of the week to week variation within months may be due to holiday effects. Four of the nine federal holidays occured during the first week of the month in FY81, three in FY82, and three in FY83. One of the holidays fell on the fifth week of a five week month in FY81 and two in FY82 and 83. It would be difficult to determine how much of the decrease in the number of contracts signed can be attributed to the week of the month effect and how much to a holiday effect or other unknown effect.

Intuitively, there should be a dropoff during a week containing one of the nine federal holidays simply because of a shorter work week. Accordingly, a 20 percent dropoff might be expected for those weeks (based upon a five day work week). To confirm the existence of a holiday effect, dropoff rates were calculated for applicants and contracts in the four supply groups. (The dropoff rate is defined as the ratio of those persons arriving during the holiday week to the previous week's total). These holiday effects were then averaged for each supply group over the three year period. The results can be seen on Tables 3a to 6a. Among applicants, several holidays exhibited dropoffs for all supply groups. Christmas and Thanksgiving led the list with averages across supply groups being .567 and .589 of the previous week's totals, respectively. These dropoffs were much higher than would be expected solely as the result of one less workday. Other strong holiday effects were observed at Labor Day (.709), July 4 (.75), and Memorial Day (.763). Washington's Birthday, Columbus Day, and Veterans Day provided negligible average effects. New Years experienced a large grand average effect (1.26), primarily because it falls on the week immediately following Christmas. While this result may not be consistent with the notion of a holiday dropoff, the ratio at New Years could prove to be useful when making week to week forecasts.

The holiday dropoff was accompanied in many cases by a post-holiday surge. This was most apparent after the Christmas-New Years holiday season. In some cases the surge sent applicant totals to much higher levels than had been experienced prior to the holidays. These surges lasted from one week to several weeks and varied by supply group and year, both within and across supply groups.

Similar results were found when examining the holiday effects for contracts. These results are shown on Tables 7a to 10a. Again, Christmas and Thanksgiving had the greatest dropoffs when averaged across fiscal year and supply groups. Memorial Day experienced slightly less of an average effect for contracts than applicants and Labor Day had a slightly greater effect. These findings indicate that a predictable holiday dropoff does take place, particularly during the weeks containing Christmas and Thanksgiving.

Key to Tables

HSM	=	All male NPS High School Graduates and Seniors
WHSM12	=	All white male NPS High School Graduates and Seniors in AFQT Categories I and II
NWHSM12	=	All non-white male NPS High School Graduates and Seniors in AFQT Categories I and II
WHSM3A	=	All white male NPS High School Graduates and Seniors in AFQT Category IIIA
NWHSM3A	=	All non-white male NPS High School Graduates and Seniors in AFQT Category IIIA

TABLE 1a Weekly Applicant Arrival Rates - Four week months

GROUP	WEEK	FY81	FY82	FY83
WHSM12	1	.175	.194	.232
	2	.228	.233	.243
	3	.259	.268	.265
	4	.337	.304	.261
WHSM3A	1	.168	.191	.227
	2	.220	.234	.234
	3	.249	.267	.259
	4	.305	.307	.280
NWHSM12	1	.152	.211	.230
	2	.247	.230	.245
	3	.277	.258	.256
	4	.324	.301	.269
NWHSM#A	1	.182	.212	.224
	2	.227	.238	.240
	3	.281	.272	.278
	4	.310	.279	.258

TABLE 2a Weekly Applicant Arrival Rates - Five week months

GROUP	WEEK	FY81	FY82	FY83
WHSM12	1	.157	.175	.175
	2	.189	.188	.185
	3	.210	.209	.226
	4	.228	.230	.230
	5	.216	.197	.185
WHSM3A	1	.148	.174	.172
	2	.201	.181	.197
	3	.208	.210	.216
	4	.240	.234	.230
	5	.203	.201	.185
NWHSM12	1	.162	.167	.191
	2	.170	.164	.177
	3	.197	.210	.222
	4	.223	.237	.232
	5	.247	.222	.177
NWHSM3A	1	.135	.178	.178
	2	.190	.199	.181
	3	.203	.206	.211
	4	.235	.235	.229
	5	.238	.182	.201

TABLE 3a

Applicant Holiday Effects - FY81

HOLIDAY	WHSM12	WHSM3A	NWHSM12	NWHSM3A
Columbus Day	1.045	.953	.846	1.021
Veterans Day	1.060	.923	.773	.935
Thanksgiving	.492	.577	.632	.681
Christmas	.496	.404	.342	.592
New Years	1.397	1.529	1.480	1.044
Washington's Birth.	.780	.687	.722	.570
Memorial Day	.816	.699	.812	.675
July 4	.746	.651	.81	.690
Labor Day	.707	.756	.74	.744

TABLE 4a

Appicant Holiday Effects - FY82

HOLIDAYS	WHSM12	WHSM3A	NWHSM12	NWHSM3A
Columbus Day	1.120	1.004	1.035	.944
Veterans Day	.986	.920	.989	.853
Thanksgiving	.536	.580	.598	.660
Christmas	.572	.514	.726	.473
New Years	1.054	1.062	.985	1.651
Washington's Birth.	.852	.779	1.042	.892
Memorial Day	.790	.657	.925	.717
July 4	.740	.813	.704	.669
Labor Day	.726	.697	.664	.598

TABLE 5a

Applicant Holiday Effects - FY83

HOLIDAY	WHSM12	WHSM3A	NWHSM12	NWHSM3A
Columbus Day	1.100	1.115	1.023	.925
Veterans Day	.934	1.027	1.127	1.090
Thanksgiving	.533	.603	.589	.592
Christmas	.642	.615	.792	.637
New Years	1.294	1.251	1.049	1.269
Washington's Birth.	.957	1.000	.965	.856
Memorial Day	.710	.756	.893	.714
July 4	.749	.691	.962	.779
Labor Day	.638	.674	.951	.611

TABLE 6a

Average Applicant Holiday Effects FY81-83

HOLIDAY	WHSM12	WHSM3A	NWHSM12	NWHSM3A	AVG
Columbus Day	1.088	1.024	.968	.963	1.010
Veterans Day	.993	.957	.963	.959	.968
Thanksgiving	.520	.587	.606	.644	.589
Christmas	.570	.511	.620	.567	.567
New Years	1.248	1.281	1.190	1.321	1.260
Washington's Birth	.863	.822	.917	.773	.842
Memorial Day	.772	.704	.887	.702	.763
July 4	.745	.718	.825	.713	.750
Labor Day	.690	.709	.785	.651	.709

TABLE 7a

Contract Holiday Effects - FY81

HOLIDAY	WHSM12	WHSM3A	NWHSM12	NWHSM3A
Columbus Day	.950	.540	1.44	1.10
Veterans Day	1.07	.86	1.28	.80
Thanksgiving	.39	.43	.57	.28
Christmas	.61	.53	.83	.61
New Years	.68	.83	.43	.73
Washington's Birth.	.79	.72	.73	.93
Memorial Day	1.02	.76	.80	.72
July 4	.49	.42	.44	.45
Labor Day	.57	.69	.42	.61

TABLE 8a

Contract Holiday Effects - FY82

HOLIDAY	WHSM12	WHSM3A	NWHSM12	NWHSM3A
Columbus Day	.95	.89	.55	.69
Veterans Day	1.06	.99	1.07	.92
Thanksgiving	.59	.60	.54	.70
Christmas	.45	.50	.62	.49
New Years	.93	.59	.81	1.03
Washington's Birth	.88	.82	.95	1.29
Memorial Day	.91	.73	.86	.58
July 4	.71	.79	.85	1.01
Labor Day	.84	.83	.89	.98

TABLE 9a

Contract Holiday Effects - FY83

HOLIDAY	WHSM12	WHSM3A	NWHSM12	NWHSM3A
Columbus Day	.96	.75	.93	.87
Veterans Day	1.00	.85	.92	.82
Thanksgiving	.66	.61	.62	.58
Christmas	.45	.60	.52	.38
New Years	1.76	1.23	1.73	1.62
Washington's Birth.	.78	.73	.63	.66
Memorial Day	.84	.89	.69	.99
July 4	.61	.63	.47	.65
Labor Day	.75	.80	.67	.63

TABLE 10a

Average Contract Holiday Effects FY81-83

HOLIDAY	WHSM12	WHSM3A	NWHSM12	NWHSM3A	AVG
Columbus Day	.95	.73	.97	.89	.88
Veterans Day	1.04	.90	1.09	.85	.97
Thanksgiving	.55	.55	.58	.52	.55
Christmas	.50	.54	.66	.49	.55
New Years	1.12	.88	.99	1.13	1.03
Washington's Birth.	.82	.76	.77	.96	.83
Memorial Day	.92	.79	.78	.76	.81
July 4	.60	.61	.59	.70	.63
Labor Day	.72	.77	.66	.74	.72

Figure 1a

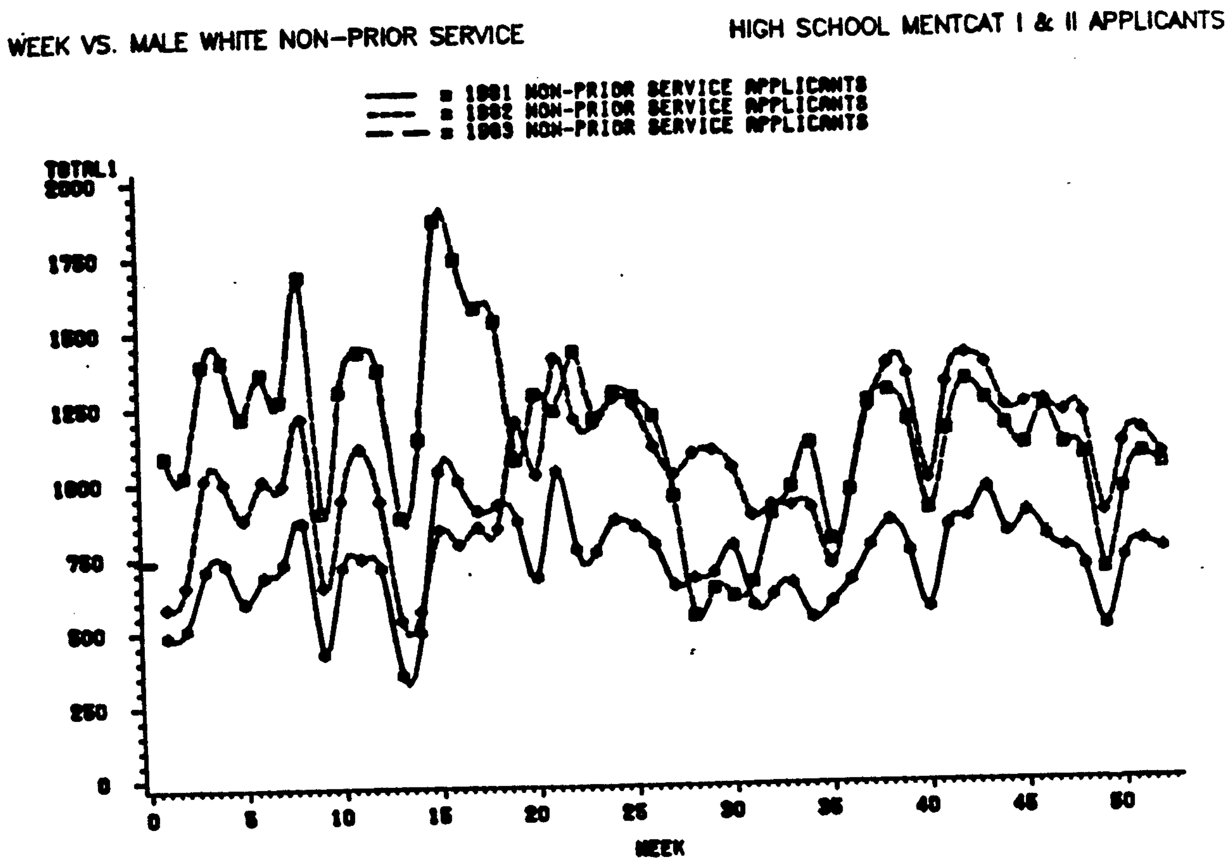


Figure 2a

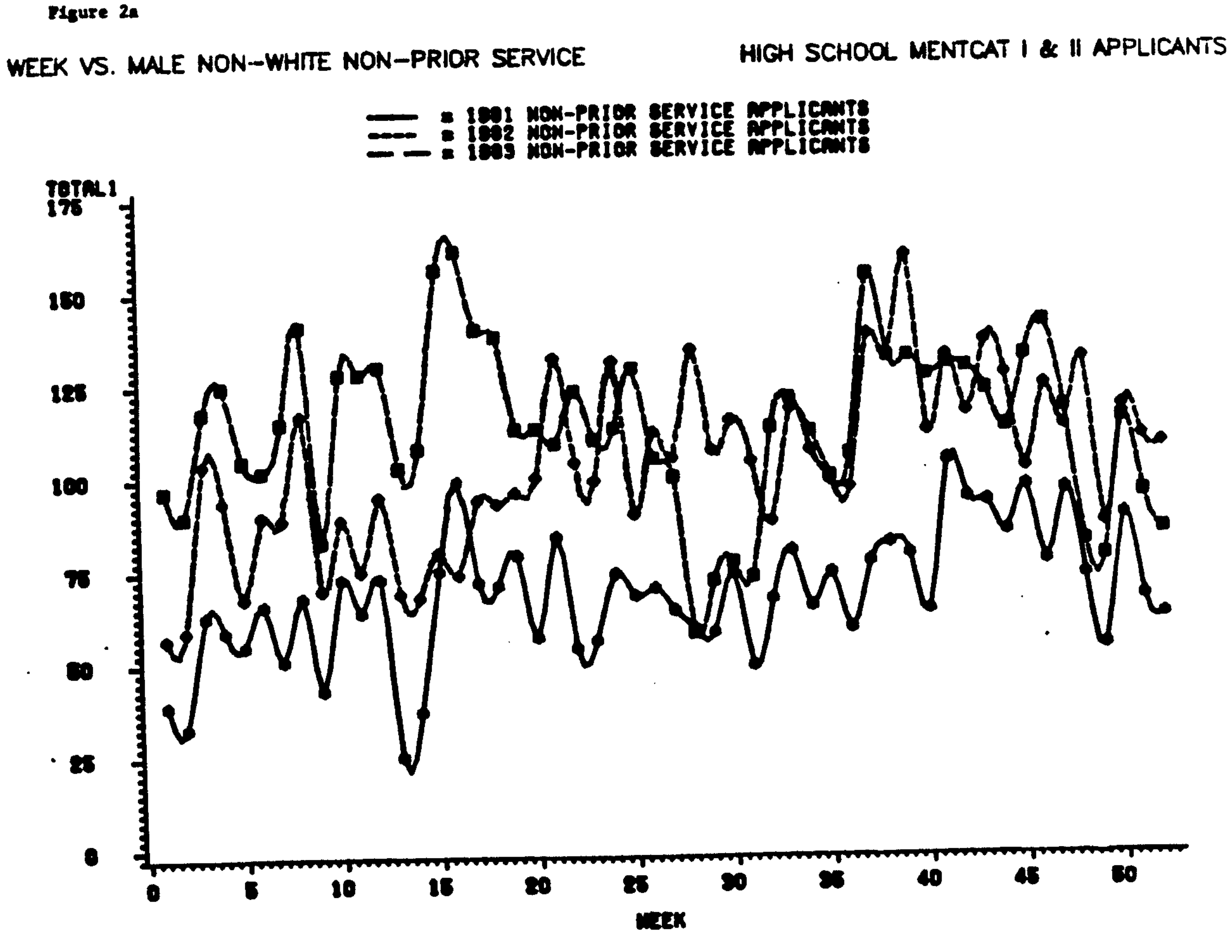


Figure 3a

WEEK VS. MALE WHITE NON-PRIOR SERVICE HIGH SCHOOL MENTCAT IIIA APPLICANTS

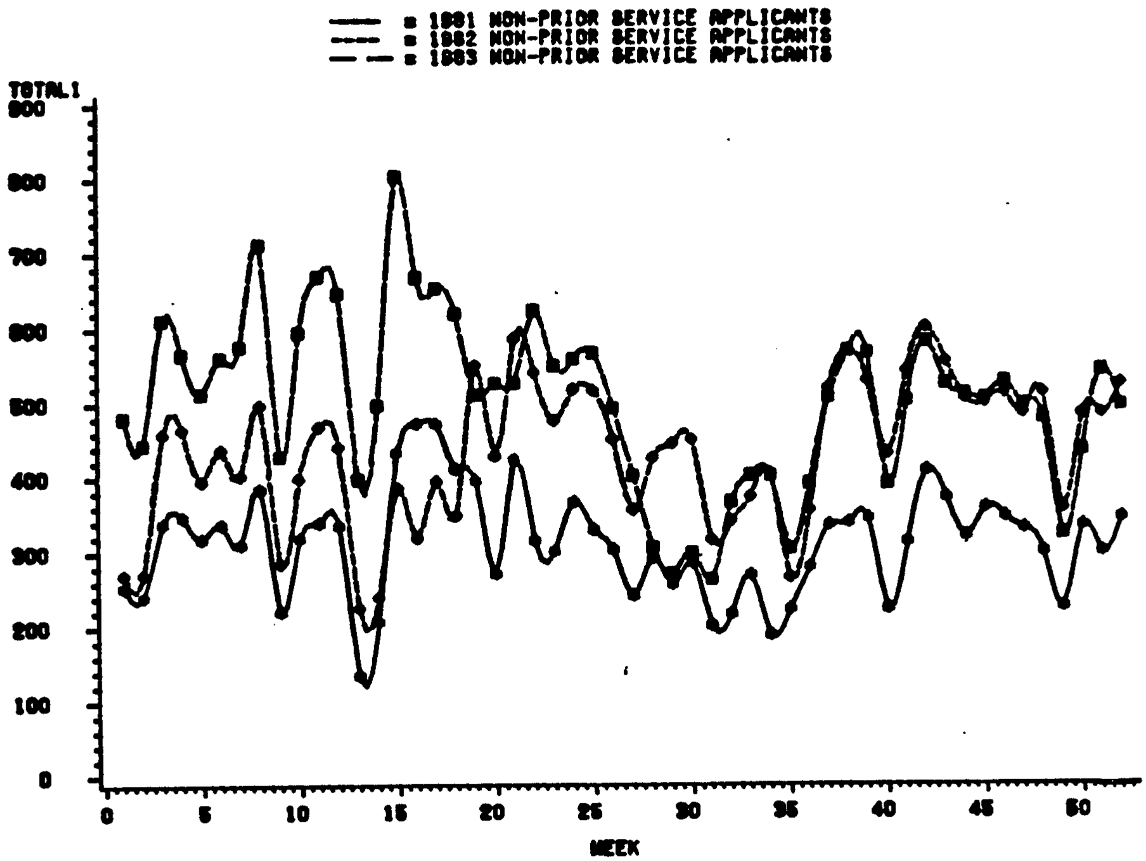


Figure 4a

WEEK VS. MALE NON-WHITE NON-PRIOR SERVICE HIGH SCHOOL MENTCAT IIIA APPLICANTS

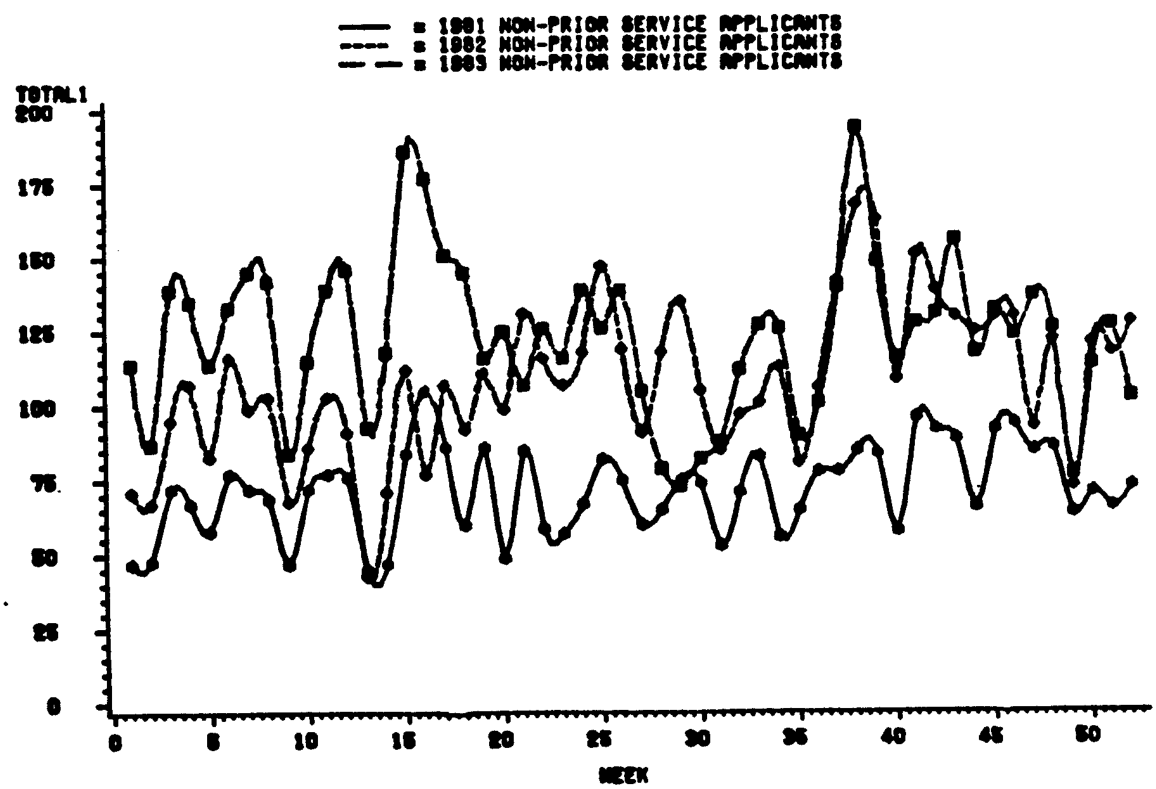


Figure 5a

WEEK VS. MALE WHITE NON-PRIOR SERVICE HIGH SCHOOL MENTCAT I & II CONTRACTS

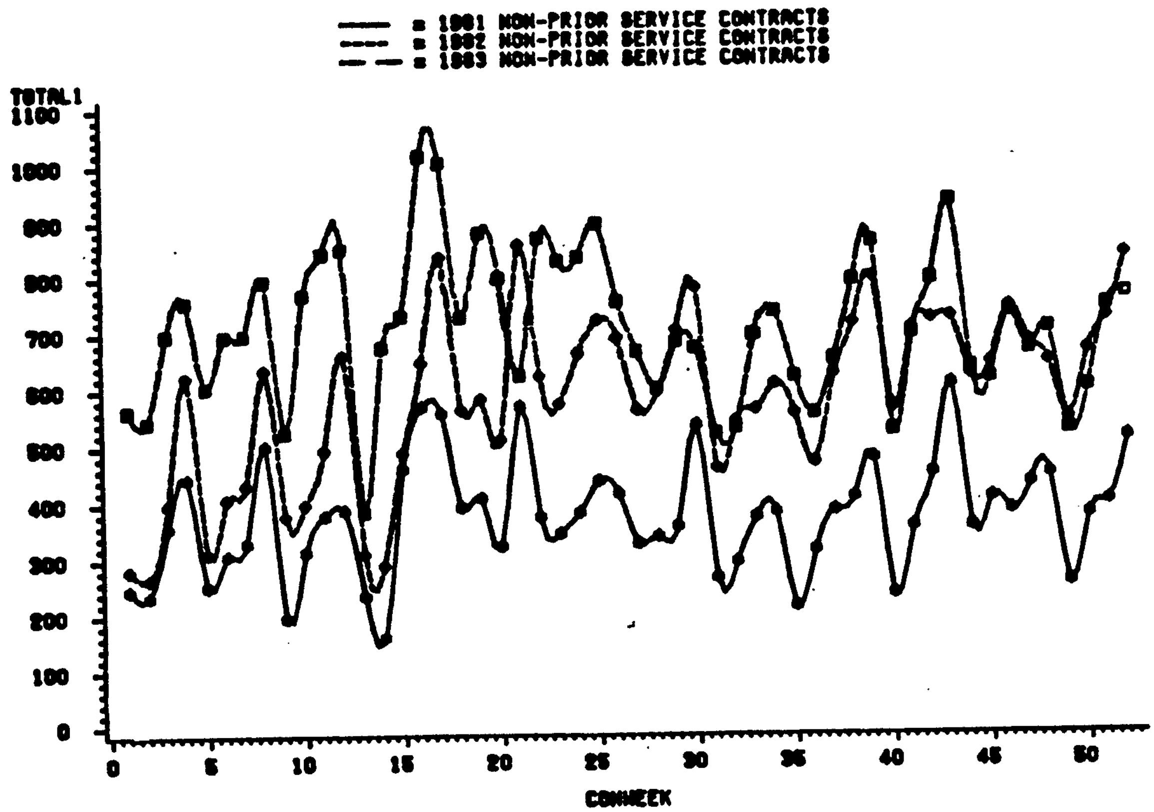


Figure 6a

WEEK VS. MALE NON-WHITE NON-PRIOR SERVICE HIGH SCHOOL MENTCAT I & II CONTRACTS

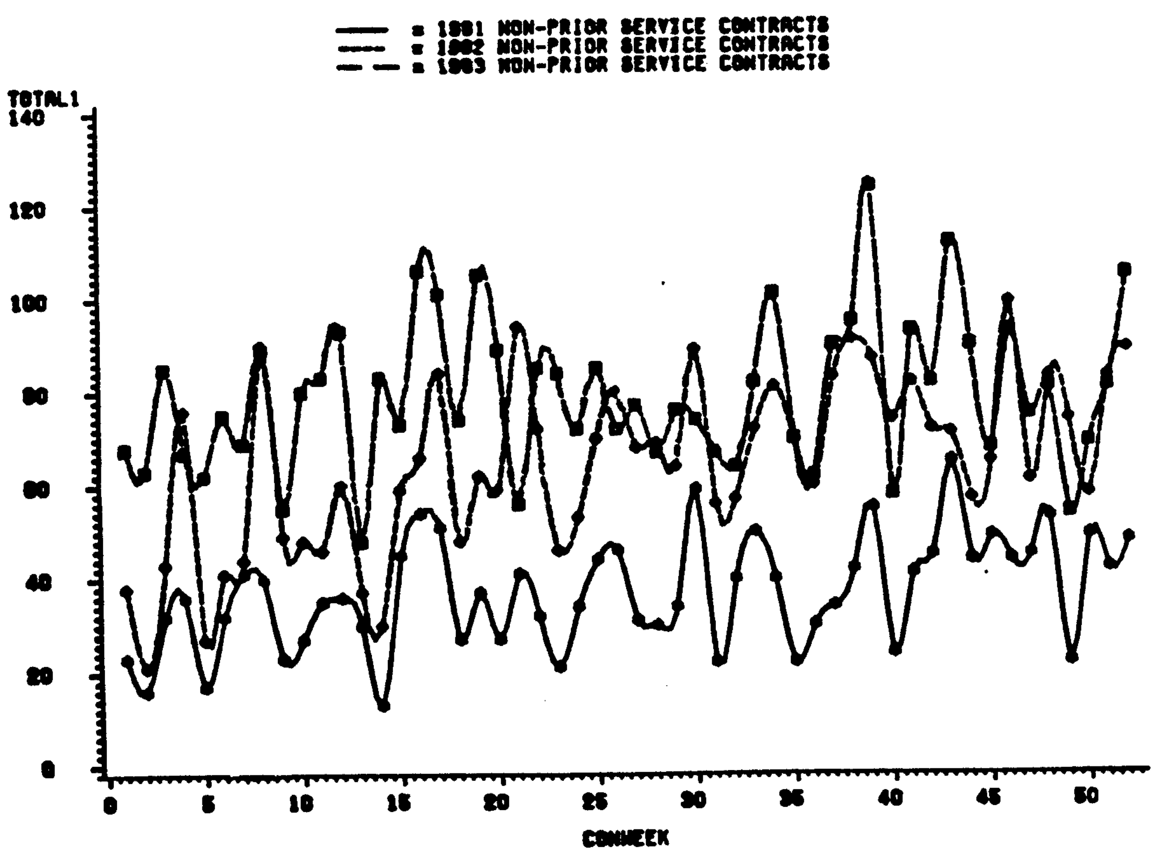


Figure 7a

WEEK VS. MALE WHITE NON-PRIOR SERVICE

HIGH SCHOOL MENTCAT IIIA CONTRACTS

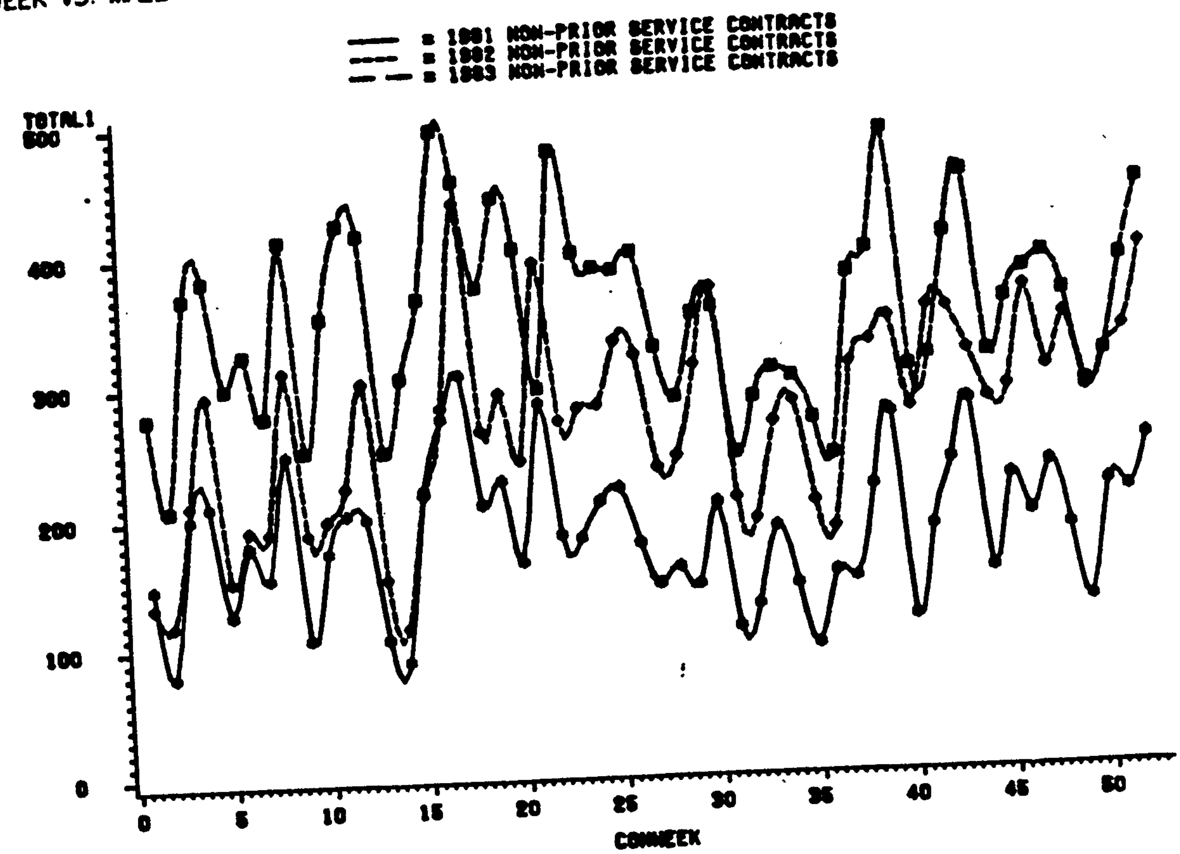


Figure 8a

WEEK VS. MALE NON-WHITE NON-PRIOR SERVICE

HIGH SCHOOL MENTCAT IIIA CONTRACTS

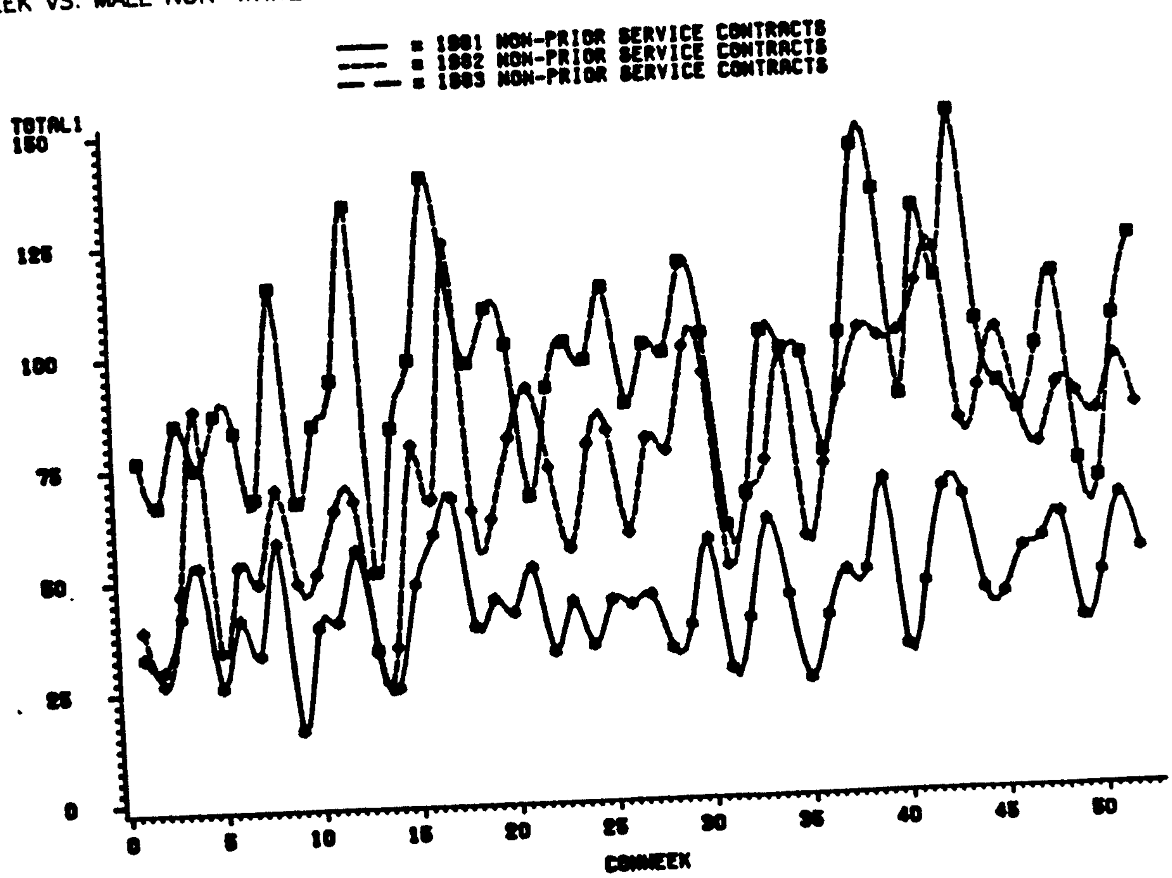


Figure 9a

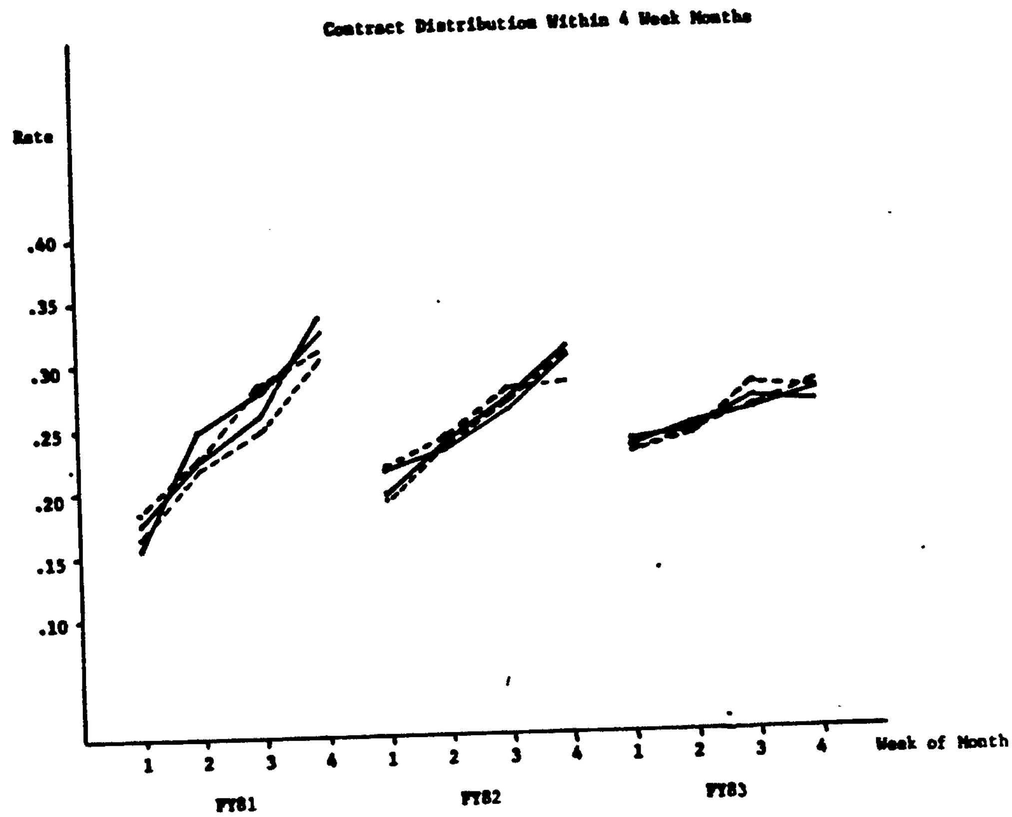
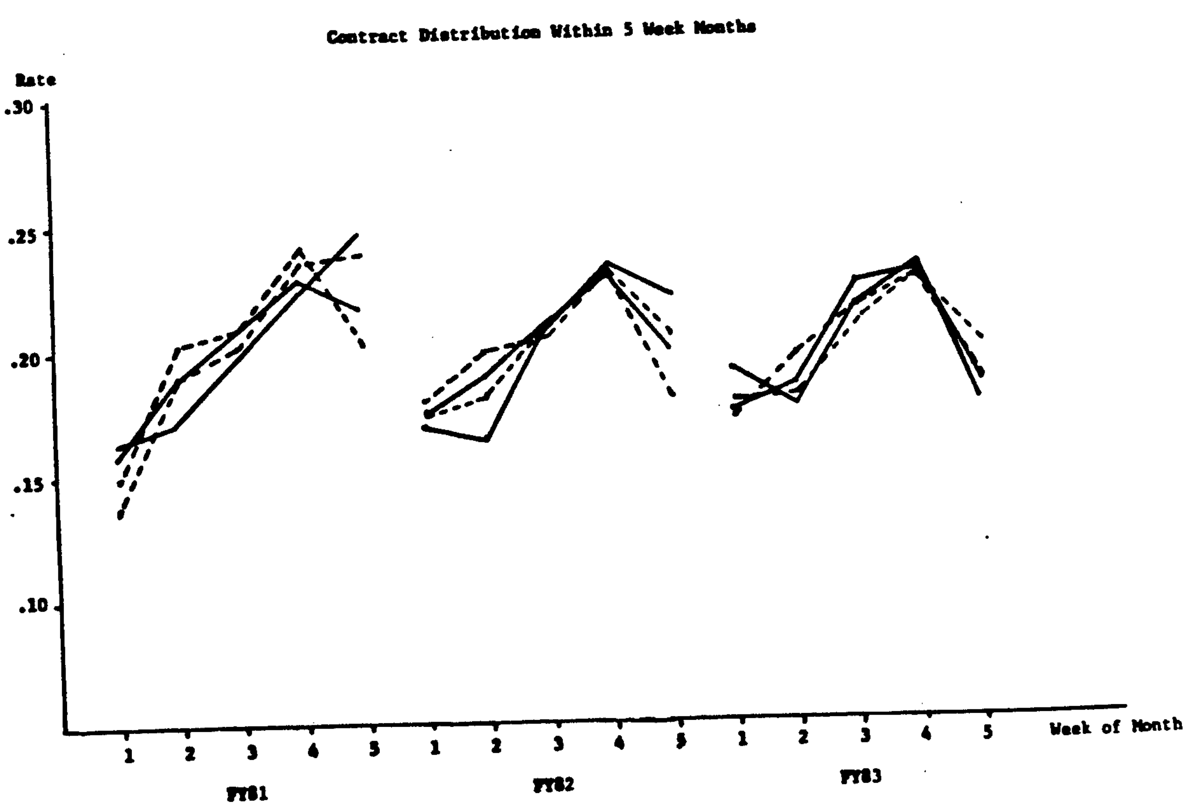


Figure 10a



Manpower and Personnel Policy Research Group

Working Paper MPPRG 89-13

SEVENTH SEMI-ANNUAL PROGRESS REPORT

AMCOS

DONALD E. ROSE, Jr.

November 1989

FOR INTERNAL ARI DISTRIBUTION ONLY

Approved by:

Timothy W. Elig

Timothy W. Elig
Chief, Manpower and Personnel
Policy Research Group

MANPOWER AND PERSONNEL RESEARCH LABORATORY

U.S. ARMY RESEARCH INSTITUTE
FOR THE BEHAVIORAL AND SOCIAL SCIENCES
5001 Eisenhower Avenue, Alexandria, VA 22333-5600

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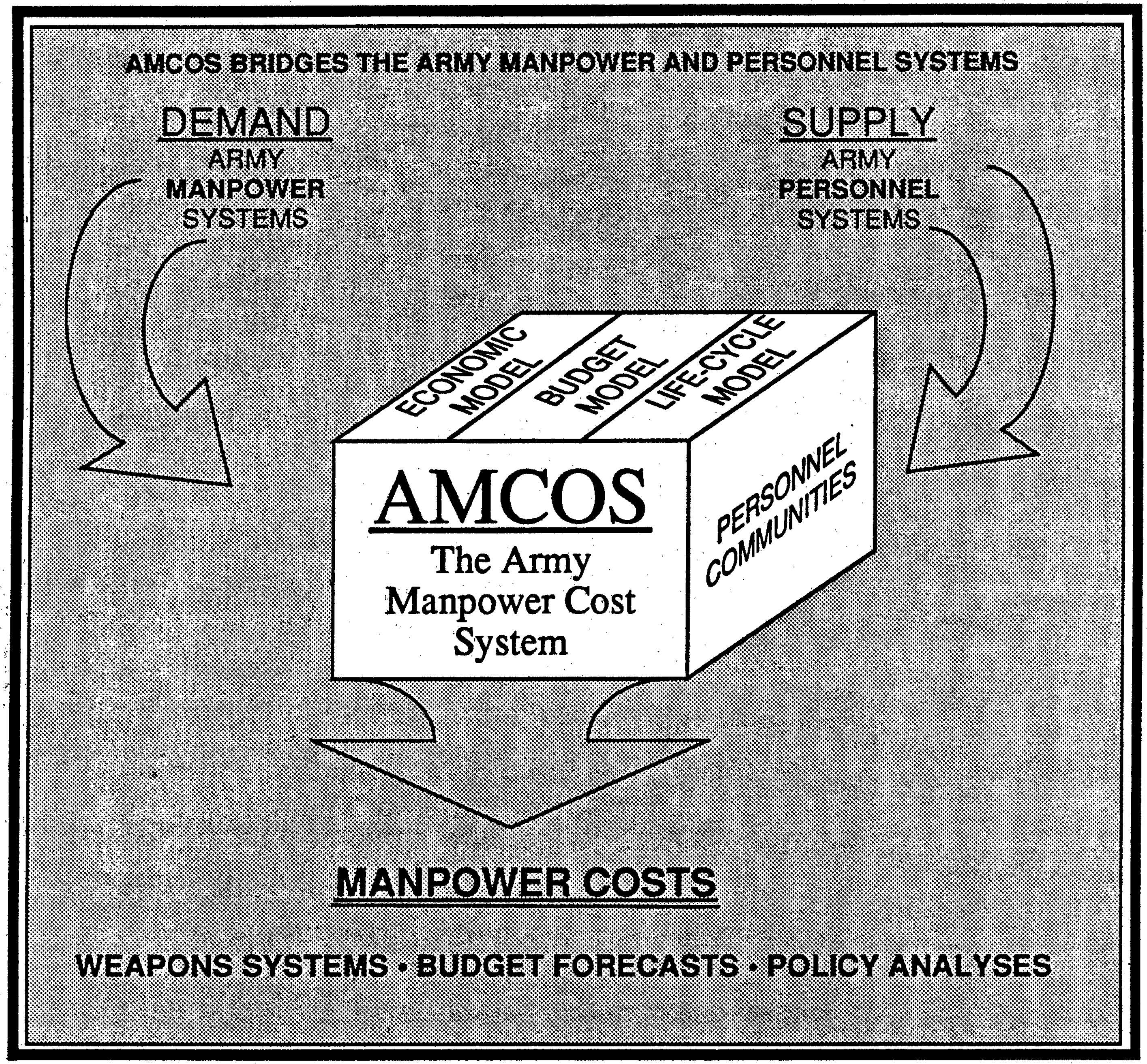

ARMY MANPOWER COST SYSTEM

OCTOBER 1989

ARMY RESEARCH INSTITUTE

SAG

Developed by
The U.S. Army Research
Institute

SRA CORPORATION

SEMI-ANNUAL PROGRESS REPORT

DONALD E. ROSE, Jr.
DANNY EICHERS
RICHARD W. HUNTER, Ph.D.

Systems Research and Applications Corporation
Arlington, Virginia

October 1989

SEMI-ANNUAL PROGRESS REPORT

Contract Number	MDA903-86-C-0106
Contract Expiration Date	March 17, 1991
Total Dollar Value	$1,629,352
Short Title of Contract Work	AMCOS
Authors	Donald E. Rose, Jr. Danny Eichers Richard W. Hunter, Ph.D.
Name of Contractor	Systems Research and Applications Corporation (SRA)
Name of Sub-Contractor	SAG Corporation
Contractor's Project Manager	Donald E. Rose, Jr.
Phone Number	(703) 558-4700
Government Sponsor	Army Research Institute
Contracting Officer's Representative	David K. Horne, Ph.D.
Date of Submission	October 1989

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EXECUTIVE SUMMARY

E.1 PURPOSE OF THIS REPORT

This paper is the seventh semi-annual AMCOS progress and financial report covering the period October 1, 1989 through March 31, 1991, submitted in compliance with Section F. of Contract MDA903-86-C-0106.

E.2 PRIORITIES FOR THE REPORTING PERIOD

On April 26, 1989, members of SRA and ARI briefed the General Officer Study Advisory Group (SAG) on the status of AMCOS. At that meeting, the SAG supported the priorities established by ARI and the Director of the Army Budget (DAB). These priorities remain unchanged for the remaining AMCOS work. Priorities for AMCOS are:

(1) Develop a budget model for all three components of Army personnel (Active, Reserve, and Civilian).

(2) Collect FY89 actual cost data and update the active, reserve and civilian life cycle cost models.

(3) Disseminate information on AMCOS service-wide.

E.3 PROJECT ACTIVITY FOR THIS REPORTING PERIOD

During the past reporting period, SRA worked on the following items:

A. Civilian Component Life Cycle Cost Model (Civ LCCM)

(1) Civilian component model version 1.0

(2) Army review of the civilian LCCM.

(2) Developed and delivered version 1.1 of civilian component LCCM.

B. Budget Analysis Model (all components)

(1) Developed budget model concept as opposed to a life cycle model concept.

(2) Designed a budget analysis model that will estimate the budget costs of a projected force inventory for each of the personnel cost components.

(3) Wrote first draft of the budget analysis model concept paper.

C. Analytical support of the Army Staff using AMCOS.

(1) Responded to Army request to estimate the cost of deactivating seven aviation units from the active and reserve components[1].

(2) Responded to eight requests for briefings on various aspects of the AMCOS LCCMs.

E.4 AMCOS PLAN

Figure E.1 summarizes the status of and long range development plan for AMCOS as of September 30, 1989.

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[1] During the General Officer's SAG held on April 26, 1989, MG Merle Freitag (Director of the Army Budget) stated that he was impressed with the speed with which AMCOS could analyze a problem. To confirm his perceptions, he requested that CEAC monitor comparison of AMCOS with the results of a recent army staff exercise. This run would estimate the cost of deactivating seven aviation units from both the active and the reserve components. SRA was able to set up the problem, analyze it, and provide a response within one day. The AMCOS results were almost identical with the army staff results but completed in one tenth the time.

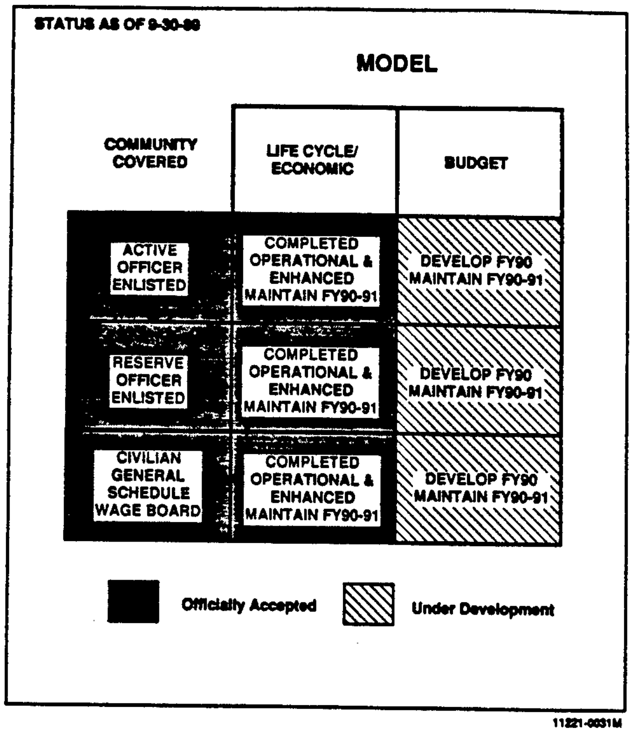


FIGURE E.1
AMCOS DEVELOPMENT PLAN

E.5 EXPENDITURES

AMCOS development is on schedule and within the amended budget. ARI increased the AMCOS budget with a contract modification effective May 5, 1989, that raised the limit of AMCOS spending to $1,629,352. We completed development of the family of life cycle cost models (LCCMs) with the delivery of the civilian life cycle cost model. In June we started conceptual development of the budget analysis model and expect delivery of the concept paper to ARI in the next reporting period. We will deliver the operational budget analysis model in the third quarter of FY90.

E.6 CONCLUSION

The Army has declared AMCOS very successful and is now institutionalizing it. For example, The Cost and Economic Analysis Center in the Office of the Assistant Secretary of the Army for Financial Management has directed its use in the estimation of manpower costs for all weapon systems.

SRA has completed the development and delivery of a LCCM for each of the three army communities; active, reserve, and civilian. The COR has accepted all three LCCMs as fully operational. We are developing the budget analysis model that we will complete in FY90. SRA will complete and deliver all the AMCOS models and their documentation by March, 1991. Appendix A discusses AMCOS enhancement and maintenance after expiration of the current contract in March, 1991.

AMCOS SEVENTH SEMIANNUAL PROGRESS REPORT

1.0 INTRODUCTION

The Army Manpower Cost System (AMCOS) is a five year research and development effort conducted by the Army Research Institute (ARI) with sponsorship of the Assistant Secretary of the Army (Financial Management) through a contract with SRA Corporation. ARI is developing this automated manpower costing systems to improve the Army's ability to conduct cost analyses.

1.1 PURPOSE OF THIS REPORT

This paper is the seventh semi-annual AMCOS progress and financial report. It covers the period April 1, 1989 through September 30, 1989. We submit this report in compliance with Section F of Contract MDA903-86-C-0106.

1.2 PURPOSE OF THE CONTRACT

To quote from the Army's request for proposal, the Army Research Institute undertook this effort:

> To design and validate a system of models (with their associated databases) to accurately estimate manpower costs of current and future weapons and other systems, to forecast manpower budget costs, and to analyze scenarios of personnel policy changes...
>
> As the Army looks to the 1990's and beyond, the shift toward increasingly sophisticated technology will be translated into sharp increases in the demand for skilled or high quality labor. At the same time, similar shifts in other sectors of the economy will contribute to a general bidding up of the price of labor. Constraints on the Army's ability to create specialists through training, coupled with the increasing cost of skilled labor, makes

it incumbent on the Army to predict manpower costs accurately.

> At present, the Army does not have an operational model to evaluate manpower costs of weapons and other systems... The objectives of this [effort] is to develop a system of manpower cost models consisting of economic cost, budget cost, and life cycle cost models...

1.3 THE PLAN FOR AMCOS

Figure 1.1 illustrates the general scope of the AMCOS effort and the progress to date. The Army has accepted delivery of the life cycle cost models (LCCM), which are all operational. The Army has formally accepted both the active and the reserve component LCCM, while the civilian LCCM is undergoing operational validation/testing. This completes the first three phases of the contract and provides the Army with a complete set of fully enhanced life cycle cost models. These models provide the Army with a set of effective tools for forecasting the manpower costs of emerging weapon systems. The fourth phase in the AMCOS development plan is the development of the budget analysis model. The last phase will include last data base updates, final enhancements, complete documentation, and delivery of the AMCOS life cycle cost and budget analysis models.

The LCCMs estimates annual manpower costs over a weapon's life cycle. They use discounting, amortization, and present values.

ARI has scheduled the budget analysis model for delivery in November, 1990. Because of lessons learned on the LCCM, SRA expects to deliver the budget analysis model earlier than scheduled. Final documentation of the project and final delivery of all AMCOS products is scheduled for March, 1991.

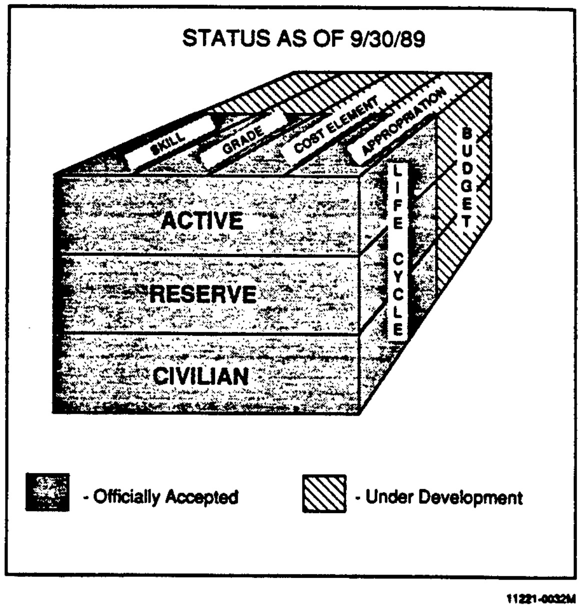


FIGURE 1.1
AMCOS OVERVIEW

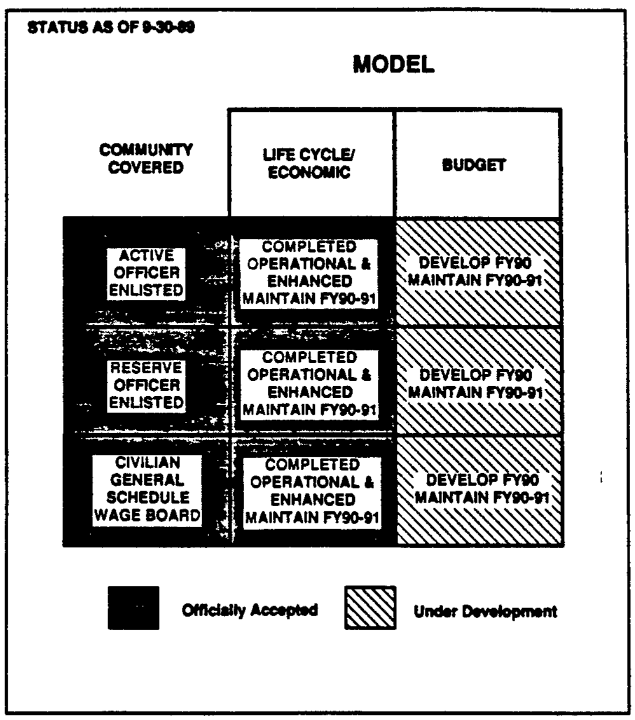


FIGURE 1.2
AMCOS DEVELOPMENT PLAN

1.4 AMCOS OVERVIEW

AMCOS includes both life cycle and budget manpower cost models. Over the past three and a half years, the AMCOS team has built the system of life cycle cost models for the active, reserve, and civilian components of Army manpower. Budget models are conceptually different from life cycle cost models. The LCCM estimates changes in cost associated with changes in the Army's manpower requirements and/or changes in the Army's personnel policies. The budget analysis model, on the other hand, develops detailed costs for a budget year. It provides the Army with a sophisticated budget cost estimation tool that is quick and easy to use. It does not use econometric tools to distribute or collect cost, but estimates the outlays expected for each budget year.

Together, the AMCOS LCCMs and budget analysis model will improve manpower cost estimating capabilities in the following areas:

New Weapon Systems. Accurate manpower cost estimates over the life of a weapon system will help in choosing the most efficient system, and in developing the most cost-effective manpower/hardware configuration for that system.

Manpower Requirements. Cost estimation by grade and occupation for the active, reserve, and civilian components, will help in choosing the most efficient manpower mix.

Personnel Policies. Explicit cost modeling of personnel policies such as tour lengths, reenlistment bonus policies, the proportion of high quality recruits and PCS moves, will allow rapid estimation of how changes in these policies affects the cost of filling specific manpower positions.

Budget Decisions. Explicit cost modeling of the effect of personnel policies on budget costs will result in better personnel planning, policy development, and budget support.

1.4.1 Modular Design

Early on in the AMCOS design process, the Comptroller of the Army approved the use of a modular design concept. We developed simple modules that we could expand as needed. Now, when needed, we can remove modules from the

model, revise or update, and re-insert them without adversely affecting other parts of the model. We update the data bases in a similar way.

1.4.2 Evolutionary Approach

The LCCMs will accept manpower requirements generated by the Personnel Strength and Composition System of the Army's Decision Support System (DSS-PERSACS), the MANPRINT process, or any "what-if" scenario. The models produce a time-phased profile of the cost of manpower over the life cycle of a weapon system. For each of the life cycle models, we developed a working model early in the process. This enabled us to use the results of actual cost estimation efforts to refine and improve the models to meet the Army's real needs.

As the research progressed, we developed selected policy modules in more detail and enhanced the cost estimation process to make it more flexible. AMCOS's modular design makes this evolutionary strategy practical. We have refined personnel policy and compensation modules and have enhanced them to meet the changing requirements of the Army and other users that emerge from real-life applications.

1.5 THE LIFE CYCLE COST MODEL

The schematic in Figure 1.3 portrays the design of the life cycle cost model. We show in the schematic that the heart of the model is the structured cost data base. That data base forms the point of interaction between the model software and the user.

1.5.1 The Structured Cost Data Base

The model takes data input from a variety of Army sources and processes them through policy modules that emulate personnel policies. This process generates costs by skill and grade that the model deposits in the structured cost data base. These costs represent the "price" of an individual soldier to

the Army.

1.5.2 User Operation

Figure 1.4 shows how the life cycle cost model operates. The user inputs the needed information through man-machine interface with the computer. Inputs include manpower requirements and cost modifications (note that the input of manpower requirements can either be automatic or manual). The model has already created a structured cost data base by processing data from various Army sources through the policy modules. The cost estimation process merges the user input with the structured cost data base to produce manpower cost estimates. As shown on the right hand side of the graphic, the user may elect a variety of output options to review the results.

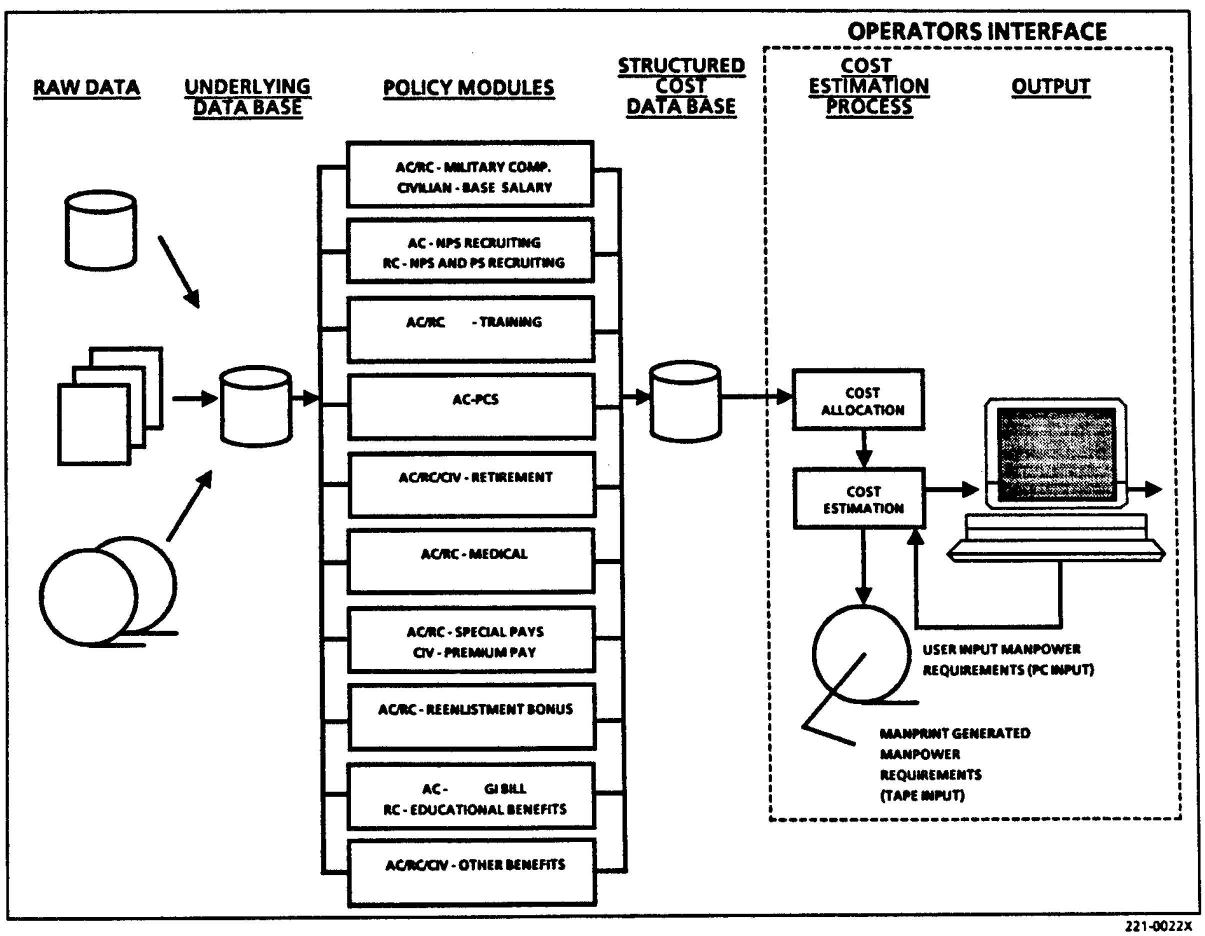


FIGURE 1.3
AMCOS SCHEMATIC FLOW DIAGRAM

USING AMCOS

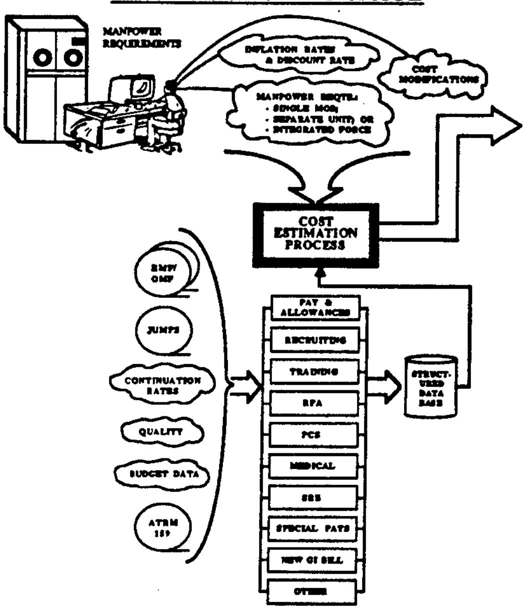
User-Defined Inputs

- **Manpower Requirements**--Manning by MOS and grade, number and type of units, phase-in/interim changes/phase-out; Accepts both manual and electronic input
- **Cost Review**--All enlisted MOSs and officer specialties; separate cost elements that roll-up to major budget appropriation categories
- **Cost Modifications**--User-specified cost policies; selection of specific pays; average versus marginal costs; costs of high versus low quality personnel; discount rates; and variable inflation rates by appropriation category

User-Oriented Outputs

- **Micro-to-Macro Focus**--Cost results for any position/unit/division combination
- **Cost Patterns**--Estimated for 1 to 30 years, discounted and undiscounted
- **Levels of Detail**--By MOS; by major element (recruiting, training, basic pay and allowances, retirement, SRB, PCS, etc); by budget appropriation category; by total costs
- **Output Options**--Display/save/print; tabular and graphic, comparative results

AMCOS USER INTERFACE



MULTIPLE OUTPUTS

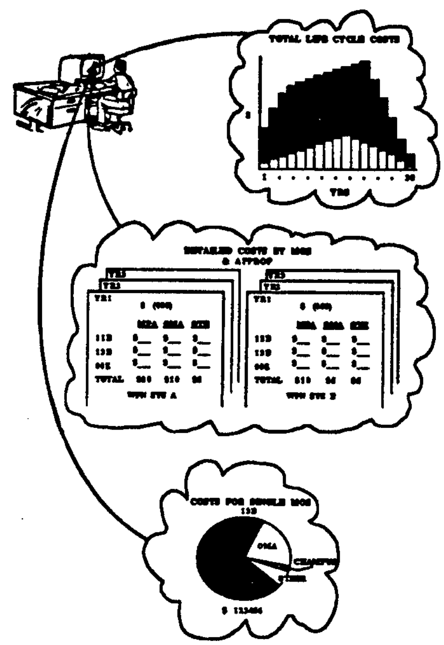


FIGURE 1.4
AMCOS INPUT/OUTPUT SCHEMATIC DIAGRAM

1.5.3 Model Features to Date

As of June 30, 1989, SRA Corporation and their sub-contractor SAG Corporation, have completed development of the AMCOS life cycle models. As these models evolved we included many features that make them user friendly. We have listed below the major features of the AMCOS life cycle cost models:

Automated Input of Manpower Requirements. Using a simple utility provided with each software package, each of the LCCMs can process the output from any source of manpower requirements. The output must be in ASCII format and each record should conform to a simple layout as specified in the user's manual. The utility program deposits the manpower requirements into the AMCOS unit data base. It lets the user estimate the costs of virtually any unit or configuration of units in the Army. CEAC requested addition of this feature, when it found during the testing of the active LCCM, that manually inputting position data proved too labor intensive for large weapon systems.

Cost Modification. The model allows the user to modify selected costs such as recruiting costs, special pays, retirement pay, and BAQ/VHA. It also allows the user to select average or marginal costs for an analysis and to select or deselect cost elements for any model run.

Use of Variable Inflation Rates and a Discount Rate. The user may specify up to five years of variable inflation rates for each of the appropriations used in AMCOS (MPA, OMA, and other). We did this so that AMCOS output would conform to DoD requirements. The user also may specify a universal discount rate to be used for calculating the present value of the cost estimation. We proposed this feature in the initial design and every version of the LCCMs has included it.

Comparison of Outputs. Decision-makers often want to compare alternatives before making a decision. This model allows the user to compare, side by side, the output from alternative AMCOS runs including composite outputs from other LCCMs. One screen will compare the cost of alternatives

including all three components of Army manpower. We added this feature after CEAC started using the LCCMs, first the active model and then for all models, to make AMCOS more responsive to the needs of Army cost analysts and the decision-makers they support.

Contains Cumulative Training Costs. The user may view the cumulative cost of training a soldier over his career. AMCOS uses the career paths specified by AR 611-201 and the costs of skill level producing courses from TRADOC's ATRM-159 to accumulate training costs. The user may view these costs with or without considering attrition. We added this feature at the request of Dr. Harry West, who was then Deputy Comptroller of the Army, so that he could measure the "human capital investment" at each grade and MOS.

User Specified Scenarios. The AMCOS models accept any scenario specified by a user for the life of a weapon system. The model accepts the users input describing the phase-in and phase out of units equipped with a particular weapon, including changes in weapons systems during their life cycle. Analysts also can use this feature to estimate the cost of force structure over time as the force changes. Again, we included this feature in the initial design and subsequently every version of the LCCMs.

Latest Cost Data. The AMCOS team updates each of the LCCMs on an annual basis using the actual data from the previous year as a basis for building a cost data base. The Army needs to consider how it will continue this feature once the current contract expires in March 1991. In addition, the user may update the pay tables at any time. The model then automatically recalculates all costs derived from military pay and allowances.

1.6 PRODUCTS DELIVERED IN THE PAST FORTY TWO MONTHS

Table 1-1 lists the products delivered under this contract during the past forty two months.

TABLE 1-1

PRODUCTS DELIVERED

DATE	TITLE
4-15-86	Briefing to ODCSPER, Program and Budget Division
5-15-86	Briefing to Deputy Comptroller of The Army
7-2-86	Technical Report: Evaluation of the Prototype (Draft)
9-30-86	Concept Paper #1: Life Cycle Cost Model Active Army Manpower (Draft)
10-15-86	Technical Report: AMCOS Information Book (Draft Working Documents)
10-31-86	AMCOS Semi-Annual Progress Report
11-12-86	Briefing to Working Level SAG
12-12-86	Briefing to Mr. Distasio, Office of the Comptroller
1-31-87	Active Component Enlisted Life Cycle Cost Model (Test Version) Delivered
1-31-87	Update to Technical Report: AMCOS Information Book (Draft Working Documents)
2-9-87	AMCOS Demonstration to Dr. Gilroy, Chief (MPPRG), ARI
3-4-87	AMCOS Demonstration to Col. Wood, Dep. Dir., CEAC
3-12-87	AMCOS Demonstration to Mr. Frantz, Dir., CEAC
3-15-87	Active Component Officers Life Cycle Cost Model (Test Version) Delivered

TABLE 1-1 (cont'd)

PRODUCTS DELIVERED

DATE	TITLE
3-30-87	Briefing to Deputy Comptroller of the Army: Operational Active Component Life Cycle Cost Model
5-15-87	AMCOS Brochure
5-31-87	AMCOS Version 2.0 (Includes Executive Shell, Automated Requirements Input, One Year Model Variable Inflation Rates, Consolidation of Enlisted and Officer Models)
7-31-87	AMCOS Version 3.0 (Includes selective cost modification/suppression, Graphics, print option and the alternate methods for computing Retired Pay Accrual)
9-28-87	In-Process-Review presented to Deputy Comptroller of the Army
10-31-87	AMCOS Version 3.1 in-process-review.
11-6-87	Briefing to the General Officer Study Advisory Group
12-31-87	AMCOS Version 3.2 with update of Structured cost data base using FY87 costs
1-31-88	Reserve Component Life Cycle Cost Model Design (draft concept paper)
3-15-88	Updated structured cost data base to include Jan 88 pay tables. All costs in FY88 dollars.

TABLE 1-1 (cont'd)

PRODUCTS DELIVERED

DATE	TITLE
4-25-88	Briefing to the General Officer Study Advisory Group
4-27-88	AMCOS AC LCCM Version 3.3 (includes optimized code)
4-27-88	One Day User Training Session
6-21-88	Briefing to TRADOC DCSRM
6-23-88	AMCOS RC LCCM Version 1.0
7-5-88	AMCOS AC LCCM Version 3.4 (includes revised unit editor and improved automated requirements download capability)
10-1-88	AMCOS AC LCCM Version 3.5 and AMCOS AC LCCM Version 1.1 (includes ability to read negative and fractional manpower requirements)
10-31-88	Civilian Component Life Cycle Cost Model Concept Paper
11-23-88	Briefing to Comptroller of the Army
3-30-89	AMCOS Civilian LCCM Version 1.0 (prototype)
3-30-89	Updated Structured Cost Data Bases based on FY88 actual costs for both the Active and Reserve Component LCCMs
4-26-89	Briefing to the AMCOS G.O. SAG
6-30-89	Civilian LCCM Version 1.1
6-30-89	Final Civilian LCCM Concept Paper

1.7 REPORT ORGANIZATION

This report is divided into seven sections and an appendix, as follows:

- introduction
- summary of project activity in the reporting period;
- descriptive list of all briefings, meetings, and visits conducted during the reporting period;
- fiscal report on project costs for this reporting period;
- description of problems encountered;
- discussion of the planned activities for the next reporting period
- conclusion.
- AMCOS maintenance and potential follow-on enhancements (Appendix A).

2.0 PROJECT ACTIVITY FOR THE SIXTH REPORTING PERIOD

2.1 PRIORITIES

On April 26, 1989, members of SRA and ARI briefed the General Officer Study Advisory Group (SAG) on the status of AMCOS. At that meeting, the SAG supported the priorities established by ARI and the Director of the Army Budget (DAB). These priorities remain unchanged for the remaining AMCOS work. Priorities for AMCOS are:

(1) Develop a budget model for all three components of Army personnel (Active, Reserve, and Civilian).

(2) Collect FY89 actual cost data and update the active, reserve and civilian life cycle cost models.

(3) Disseminate information on AMCOS service-wide.

2.2 OUTLINE OF PROJECT ACTIVITY

During the past reporting period, SRA worked on the following items:

A. Civilian Component Life Cycle Cost Model (Civ LCCM)

(1) Civilian component model version 1.0

(2) Army review of the civilian LCCM.

(2) Developed and delivered version 1.1 of civilian component LCCM.

B. Budget Analysis Model (all components)

(1) Developed budget model concept as opposed to a life cycle model concept.

(2) Designed a budget analysis model that will estimate the budget costs of a projected force inventory for each of the personnel cost components.

(3) Wrote first draft of the budget analysis model concept paper.

C. Analytical support of the Army Staff using AMCOS.

(1) Responded to Army request to estimate the cost of deactivating seven aviation units from the active and reserve components.

(2) Responded to eight requests for briefings on various aspects of the AMCOS LCCMs.

2.2.1. Civilian Component Life Cycle Cost Model

2.2.1.1 Civilian Component Model Version 1.0

As we reported in the last semi-annual report, SRA delivered version 1.0 of the civilian component LCCM on March 30, 1989. The intention was to offer the Army a basic model that they could then tailor to the specific needs of various Army communities interested in a civilian life cycle cost model.

2.2.1.2. Army Review of the Civilian LCCM

SRA briefed version 1.0 of the civilian LCCM to the General Officer Study Advisory Group (SAG) on April 26, 1989. After that briefing, SRA distributed copies of the model to several potential users for their review. SRA then briefed and demonstrated the AMCOS civilian model to these users, besides CEAC and ARI, to determine if they wanted model modifications or enhancements. During the briefing of the civilian LCCM, several users indicated they liked the model. However, none of the users articulated any applications that would require changes or enhancements to the basic model.

As a result of comments received from the potential users, SRA recommended that we make minor improvements to version 1.0 and minimize resource expenditures until army users establish requirements for enhancements. The COR decided that version 1.0 of the civilian model, with minor improvements, met the needs of the army. The COR then directed SRA to complete version 1.1 of the civilian LCCM and then start development of the budget

analysis model. As of September xx, 1989, the COR accepted the civilian LCCM, version 1.1, as fully operational.

2.2.1.3. Civilian Component LCCM Version 1.1

The ARI/SRA AMCOS team completed and tested version 1.1 of the civilian LCCM. This version has the same menu selection as the previous LCCMs. It includes features that allow the user to select and deselect cost elements, to specify work plans, change retirement plan mixes, and toggle between average and marginal costs. Version 1.1 also includes a modified utility program. This program allows users to capture Tables of Distribution and Allowances (TDA) requirements from external data bases and import them to the AMCOS shell.

2.2.2. Budget Analysis Model (all components)

2.2.2.1. Budget Model Concept

A LCCM may incorporate econometric processes such as discounting, amortization, and present value of future costs and benefits. A manpower life cycle cost model calculates the annualized cost of manpower resources expended over the life of a weapon system. In contrast, a manpower budget analysis model calculates the dollars that the Army must spend during a given year to fill, maintain, and support a particular force structure. Although these functions appear similar, each implies a difference in model design. A budget model does not attribute any current costs to future uses. It also does not consider any future costs that might ultimately result from this year's decisions.

2.2.2.1. Design of the Budget Analysis Model

Using the structured cost data base from the LCCM for costs, the AMCOS team designed a budget analysis model. The model will project the army's

personnel inventory over the budget and POM years, capture numbers of accessions, reenlistments, losses and promotions, and estimate the costs expended during a given fiscal year.

We included in our software design process an estimate of the computer system requirements to ensure that our customer can use the end product on their hardware. We then developed the design flow chart (Figure 2.1). This allowed us to view the whole design at once to ensure that all pieces flowed together properly.

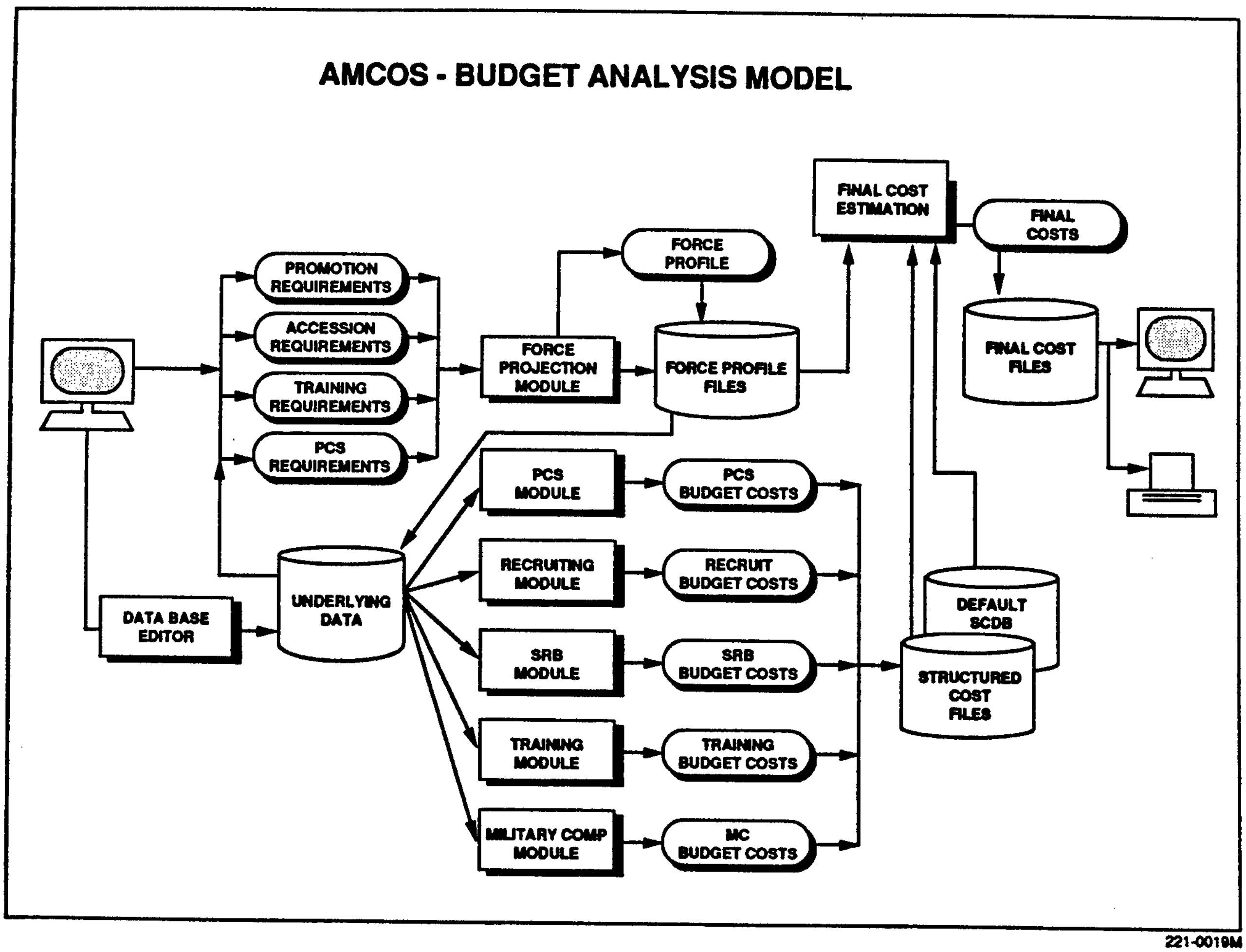


FIGURE 2.1
BUDGET ANAYSIS MODEL FLOW CHART

2.2.2.2. First Draft of the Budget Analysis Model Concept Paper

The first draft of the budget analysis concept paper presents SRA's conceptual design. This draft is still undergoing revisions based on SRA internal review.

2.2.3. Analytical Support of the Army Staff Using AMCOS

2.2.3.1. Response to Army Request for Information

During the General Officer's SAG held on April 26, 1989, MG Merle Freitag (Director of the Army Budget) stated that he was impressed with the speed with which AMCOS could analyze a problem. To confirm his perceptions, he requested that CEAC monitor comparison of AMCOS with the results of a recent army staff exercise. This run would estimate the cost of deactivating seven aviation units from both the active and the reserve components. SRA was able to set up the problem, analyze it, and provide a response within one day. The AMCOS results were almost identical with the army staff results but completed in one tenth the time.

2.2.3.2. Responses to Requests for Briefings on the AMCOS LCCMs.

During the past reporting period, the AMCOS team responded to eight requests for information briefings. Some of these briefings were informal and required minimal resources, although others required rather extensive preparations. A complete listing of these briefings is in chapter 3 below.

2.3 PRODUCTS DELIVERED THIS REPORTING PERIOD

Table 2-1 lists the products delivered during this reporting period.

TABLE 2-1

PRODUCTS DELIVERED DURING THIS REPORTING PERIOD

PRODUCT	DATE
Briefing to the AMCOS G.O. SAG	April 26, 1989
Civilian LCCM Version 1.1	June 30, 1989
Final Civilian LCCM Concept Paper	June 30, 1989

2.3 PRODUCTS DELIVERED THIS REPORTING PERIOD

Table 2-1 lists the products delivered during this reporting period.

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PRODUCT	DATE
Briefing to the AMCOS G.O. SAG	April 26, 1989
Civilian LCCM Version 1.1	June 30, 1989
Final Civilian LCCM Concept Paper	June 30, 1989

3.0 BRIEFINGS, MEETINGS, AND VISITS

Dr. David Horne of ARI, the COR, continues as ARI's key participant in the development team. He attended many meetings and exchanged many telephone calls during the reporting period. The following list summarizes the key briefings, meetings, or visits conducted by SRA in the reporting period.

3.1 General Officer SAG Preparation. Mssrs. Hogan and Rose, SRA Corporation, and Dr. Horne, ARI, met on April 17, 1989, and discussed the content of the upcoming general officer SAG. They reviewed slides and walked through a demonstration of the AMCOS reserve component and civilian component life cycle cost models.

3.2 General Officer SAG Pre-brief to Director, CEAC. Messrs. Hogan and Rose, SRA Corp., Mr. Mairs, SAG Corp., and Dr. Horne, ARI visited CEAC on April 24, 1989, to present a pre-brief of the general officer SAG to Mr. Merv Frantz, Director of CEAC. The briefing covered the changes made to the civilian component model as a result of comments from the Army and demonstrated the reserve component life cycle cost model.

3.3 General Officer SAG. Dr. Horne, ARI and Mssrs. Rose and Hogan, SRA Corp. presented a briefing on the status of the AMCOS contract to the AMCOS general officer SAG on April 26, 1989. The briefing included a demonstration of the reserve component life cycle cost model. MG Freitag, cosponsor of the AMCOS contract, asked SRA and CEAC to run a validation run of AMCOS. His intent was to compare AMCOS output to recent calculations made in support of a recent Army decision to deactivate several helicopter units. The consensus was, if AMCOS could do the same calculations in a few hours (it did), versus the two weeks it took the Army Staff, then the Army Staff should be using the models.

3.4 Meeting with CACI. On April 26, 1989, Mr. Rose, SRA met with Mr. Fields, CACI to discuss the integration of AMCOS into the family of models used by the Army to evaluate resources needed to maintain the force. As a result of this

meeting, CACI included a summary of the AMCOS system of models in a report they prepared for the Army PA&E office.

3.5 Meeting with LTC Lund. Mr. Rose, SRA Corp. visited LTC Lund, Army PA&E on May 2, 1989. They discussed the parameters used by the Army to estimate the cost of deactivating several AH-64 units in both the reserves and active forces. These same parameters then fed the AMCOS LCCMs to obtain a cost estimate for the same thing. Mr. Rose also used the visit to provide LTC Lund with a copy of the AMCOS active and reserve component LCCMs and to provide him with user training.

3.6 Customer Service Visit to CEAC. Mr. Rose and Ms. Canuel, SRA Corp. visited CEAC on May 4, 1989, to troubleshoot the installation of the most recent version of AMCOS. CEAC had been having problems installing the model on all their machines. As a result of that visit, SRA discovered a minor problem in the installation software that they quickly fixed. CEAC then installed the AMCOS software on their machines with no problems.

3.7 Meeting with AMC Cost Analyst. Mr. Berson, AMC Cost Analysis Division and Mrs. Matthews, CEAC met with Mr. Rose, SRA Corp. to discuss model methodologies. Specifically, the model's method for calculating training costs interested Mr. Berson. They were under the misperception that AMCOS included training costs incurred by units.

3.8 Briefing to Army Staff at Pentagon. Mssrs. Hogan and Rose, SRA Corp. briefed the civilian LCCM to interested members of the Army Staff to include, DCSPER-DCP, ASA(FM)-Budget Mgt Division, USAR, NGB, and Army PA&E. The purpose of the briefing was to present the civilian LCCM to potential users and obtain their input on necessary modifications to meet the needs of the Army. The audience received the model well but provided no useful comments for modifying the model. Mr. Rose scheduled a follow on briefing with Mr. Snyder, DCSPER-DCP.

3.9 Budget Analysis Model (prototype) Briefing to ARI. Mssrs. Eichers, Hogan, and Rose, SRA Corp. and Mr. Mairs, SAG Corp. presented a prototype of the budget analysis model to Dr. Horne, ARI, and LTC Martell, ODCSPER. The concept demonstrated with the prototype model was well received and LTC Martell seemed very interested in the potential application of the model for analyzing enlisted accessions. LTC Martell also offered to act as a coordinator for setting up a briefing of the prototype to other members of the ODCSPER staff who would use the model.

3.10 Meeting at DCSPER-DCP to Brief the Civilian LCCM. On June 2, 1989, Mr. Rose and Ms. Canuel, SRA Corp. briefed the civilian LCCM to MR. Snyder and his staff. Mr. Synder's biggest concern was a perception that any modification to the civilian model would cost the Army additional dollars. Mr. Rose explained that ARI had already paid for modification to the model. Major revisions, however, would cost the Army more money.

3.11 AMCOS Team Meeting. The AMCOS team, including Mssrs. Eichers, Hogan, and Rose from SRA Corp. and Mssrs. Mairs and Mackin of SAG Corp., met to discuss the evolving budget analysis model concept on August 9, 1989. The AMCOS team decided to develop a list of questions that users would most likely ask the model and include it in the forthcoming Budget Analysis Model Concept paper.

3.12 DCSPER Visit. On August 16, 1989, Mssrs. Eichers and Rose visited ODCSPER to demonstrate a prototype of the budget analysis model to selected action officers who would be using it. In addition, Mr. Rose solicited comments from the ODCSPER action officers to determine their needs. This information would allow SRA to rank the design features in the model. ODCSPER action officers wanted the model to recommend optimal application of budget cuts to the reenlistment program. The model will help in this analysis by showing costs of various alternatives, but it cannot compare benefits. That capability would require a whole new concept of operation that exceeds the current contract specifications.

3.13 <u>ASA(FM) Visit.</u> Mr. Rose visited Mr. Mayfield, MPA Budget Division, ASA(FM) on August 18, 1989. During this meeting they discussed the methodology used by AMCOS to calculate the cost estimation of military pay and allowances. The army's MPA budget analysts expressed an interested in finding an alternative method for estimating the MPA budget. Mr. Rose explained the look-up table procedure used by AMCOS to estimate pay and allowances. Then Mr. Rose installed the active component LCCM, but suggested that SRA was building a budget analysis model that would be more suited to their needs and asked Mr. Mayfield if they would like to participate in the review of the test version of the model. He stated they would.

3.14 <u>Concept Briefing to COR.</u> On August 25, 1989, the AMCOS Team (SRA and SAG Corp.) briefed Dr. Horne, ARI, on the budget analysis model concept to include a discussion of the major issues and how SRA intended to resolve them. As with other models, we will start simple and add complexity if the Army wants it and funds it.

3.15 <u>Concept Briefing #2 to COR.</u> Mssrs. Rose and Eichers, SRA Corp. and Mssrs. Mairs and Mackin, SAG Corp., met with Dr. Horne, ARI to present a revised model concept on September 20, 1989. The purpose was to obtain Army approval before we started to code the model. Dr. Horne gave us that approval.

4.0 FISCAL STATUS REPORT

4.1 SUMMARY OF EXPENDITURES

Table 4-1 shows the staff-months expended and dollars obligated by month for April 1989 through September 1989. It also shows cumulative labor and cost for the contract to date for each month. We have shown the labor and expenditures remaining in the contract at the end of the reporting period as well. At the end of September 1989, the contract had used 161 staff-months at a total cost of $1365 thousand. SRA also received a contract modification effective May 5, 1989, that raised the limit of AMCOS spending to $1629. As a result of that contract modification, we have approximately 29 staff months and $264 thousand remaining in the contract.

TABLE 4-1
EXPENDITURES

Month	Staff-Months Monthly	Staff-Months Cumulative	Obligations ($ thousands) Planned	Obligations ($ thousands) Obligated	Obligations ($ thousands) Cumulative
March*	-	145	--	--	1201
April	2	147	28	28	1229
May	2	149	28	41	1270
June	1	150	28	21	1291
July	2	152	28	13	1304
August	4	156	28	25	1329
September	5	161	28	36	1365
Remaining		29			264

* Total from previous Semi-Annual Report

During the past six months, SRA's monthly expenditures reflect the transition

of work from the LCCM to the Budget Analysis model. The work during the first half this reporting period focused on completing the LCCMs and starting work on our last model, the budget analysis model. The average monthly expenditure during the reporting period was $27 thousand.

Because of the nature of the labor mix during this period, the cost was somewhat higher than over the life of the contract. The average cost to date is under $8.5 thousand per staff-month. The average expenditure per staff-month for this six-month period was $10.25 thousand.

The cumulative expenditure to date is $1,365,000 and compares favorably with the planned cumulative expenditure of $1,399,000 through September 30, 1989. Figure 4.1 compares the cumulative planned costs per month with actual cumulative expenditures per month for the reporting period. At the end of this reporting period, cumulative expenditures are about $34,000 below the planned level.

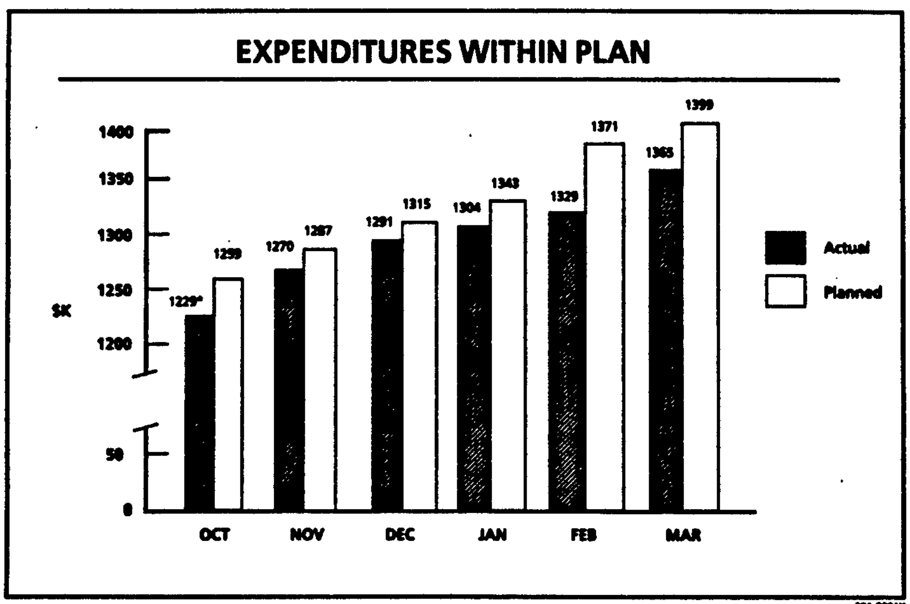

FIGURE 4.1
CUMULATIVE EXPENDITURES

4.2 STAFF-DAY ACCOUNTING BY PROFESSIONAL

Table 4-2 provides a detailed break down of the professional staff-time expended during the period by task and by staff professional (including subcontractor personnel). For comparison purposes the block just below the table entitled "planned", provides the staff days planned by task as stated in the previous semi-annual report. Professional staff participation in AMCOS is in balance with the work achieved in this reporting period and is consistent with the plan for this period.

TABLE 4-2

PROFESSIONAL STAFF-DAYS PER PERSON PER TASK

	Task 1	Task 2	Task 3	Task 4	
Staff Professional	Concept Development	Model Development	Model Validation	Briefing SAG Etc.	Total
SRA					
Black	6			3	9
Wagonner		26	15	3	44
Eichers		74	43	10	127
Gregg	2	1	1	1	5
Hogan	5			4	9
Hunter	2		6		8
Reed		4			4
Rose	23	31	18	25	97
Rubens	6				6
Simmons	3				3
Slywester		1			1
Other		5	5	5	15
Subtotal	47	142	88	51	328
SAG	36	42	18	21	117
TOTAL	83(19%)	184(41%)	106(24%)	72(16%)	445(100%)
PLANNED	100(20%)	200(40%)	130(26%)	70(14%)	500(100%)

Task 1 - Prepare the Concept Paper for formal publication.

Task 2 - Develop and enhance LCCM models.

Task 3 - Validate LCCM model.

Task 4 - Interact with Army sponsors, train users, and demonstrate the finished product. (See Chapter 3)

Tasks 1 and 2, model development and validation, represented most of our work (65%) during the reporting period. Task 3, Concept development, used 18% of our time and focused on the design of the budget analysis model. Finally, we spent 16% of our time on task 4 briefing and training army users. Only task 4 exceeded the planned level of effort and the total was well within budgeted 500 staff-days level of effort.

4.3 PLANNED EFFORT BY TASK

During the next six months (through March 1990), SRA will develop and deliver three major products. A budget analysis model design paper, a Budget Analysis Model (test), and the update of the cost data bases for all models completed to date. In addition they will start modification of the test Budget Analysis Model based on user feedback.

Table 4-3 summarizes our estimated six-month work load by staff days and expenditures by task for the next reporting period.

TABLE 4-3

PROJECTED RESOURCES

	TASK 1	TASK 2	TASK 3	TASK 4	TOTAL
STAFF DAYS	65	95	35	35	230
EXPENDITURES ($K)	26	38	14	14	92
AS % OF TOTAL	28%	41%	15%	15%	100%

4.4 AMCOS SPENDING PLAN

Figure 4.2 shows the expenditures, both actual and planned, by quarter for the entire five year contract as modified by the Army Research Institute in the last contract modification. The clear area displays the actual expenditures by quarter for a total cost of $1365 thousand. The hashed area shows planned expenditures for the remainder of the contract. They total $204 thousand, with $134 thousand planned for FY90.

The AMCOS team will concentrate on completion of an operational version of the budget analysis model during this next reporting period (first half of FY90) at a cost of about $100 thousand. This model will provide the user with a capability to analyze personnel policy decisions and measure the impact on the budget. The model will use the structured cost data base from the LCCMs but will integrate an inventory projection module to allow near term projection of costs. In addition, maintenance of all previously developed models during that year will cost about $34 thousand. We propose to spend the remaining funds in FY91 ($70 thousand) updating all models, writing the final report, and transferring the entire system of models to the Army. If the Army wants further enhancements to AMCOS, or additional costing support like that called for in baseline cost estimates, then it would need to increase the contract ceiling to add funding above this plan.

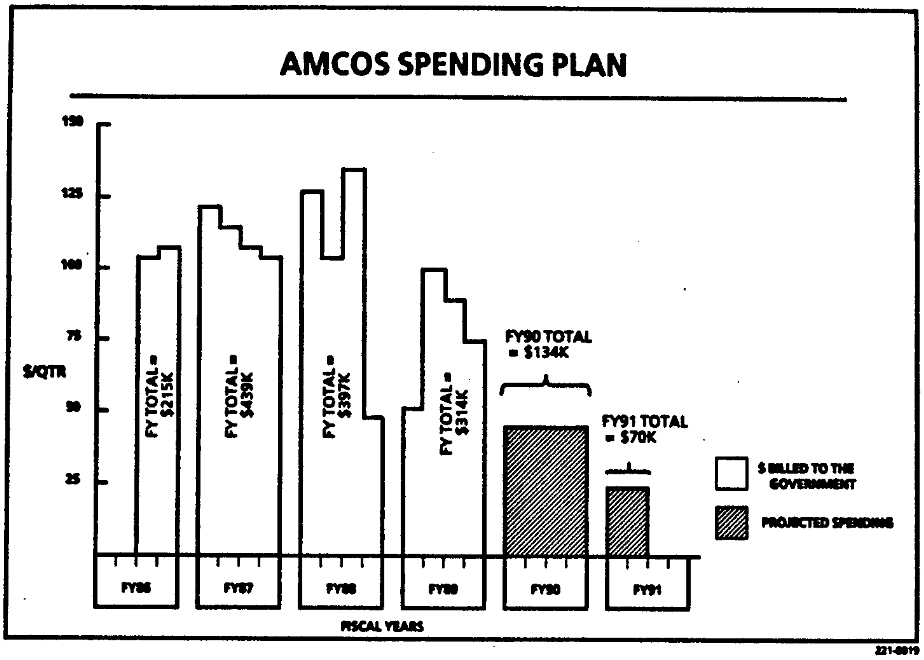

FIGURE 4.2
AMCOS SPENDING PLAN

The plan calls for the AMCOS to be transferred to the Army with final documentation delivered in March 1991. The AMCOS team will complete all models by September 1990, but it will still need to update data bases and to complete documentation in FY91.

4.5 NEAR-TERM PRODUCT SCHEDULE

Table 4-4 below shows the near term products for AMCOS to be delivered in the next nine month period.

TABLE 4-4

NEAR TERM PRODUCTS SCHEDULE

PRODUCT	DATE
1. Budget Analysis Model Draft Concept Paper	September 31, 89
2. Budget Analysis Model (Test)	December 31, 89
3. Update of all AMCOS Models with FY89 Data	January 31, 90

5.0 PROBLEMS ENCOUNTERED

5.1 TIMELINESS OF THE ATRM-159

As we reported in the previous semi-annual report, TRADOC has been having some difficulty in updating the ATRM-159. TRADOC has not updated the report's course costs since December 1986. TRADOC has reprogrammed the model that processes the raw data received from the field; however, they are having difficulty processing the raw data because of inconsistencies among the various training installations' reports. As a result, TRADOC has not updated the ATRM-159 to reflect FY88 costs. TRADOC has completed the processing of several Army schools and will send us that data so that AMCOS can be reprogrammed to receive the new data. TRADOC has assigned a new analyst on the report full time and will work on this report until the FY88 report is complete. There is no estimate as to when that will be complete. Meanwhile, AMCOS will continue to use the previous ATRM-159 data adjusted by estimated inflation factors.

5.2 SYSTEM ENHANCEMENT AND DATA BASE MAINTENANCE

Execution of this contract conentrated on building simple models, getting them to the users early in the contract, enhancing them as the users confirmed needs for more sophistication through hands on use of the models. This procedure has proved highly successful, but resulted in front loading the work as illustrated in Figure 4.2 in the previous chapter. If the government determines that it wants additional major enhancements to the models or their data bases during the last year of the contract, it will need to add to the contract ceiling. The Army also needs to consider how it will modernize the models and how it will accomplish annual data base updating after the end of this contract in March 1991. Appendix A suggests some ideas.

6.0 CONCLUSION

Work on AMCOS has been very successful. During the 42 months of contract performance through this reporting period, SRA has delivered 32 products on time and within cost. Figure 6.1 shows the cumulative cost plan for the duration of the contract by six month reporting periods and SRA's performance to date. Notice that we are within cost for each of the seven reporting periods covered through September 1989.

SRA has completed the development and delivery of a LCCM for each of the three army communities; active, reserve, and civilian. The COR has accepted all three LCCMs as fully operational. During the next year we will complete development of the budget analysis model. In FY91, SRA will update the data base for the last time and we will complete and deliver all the AMCOS models and their documentation by March, 1991.

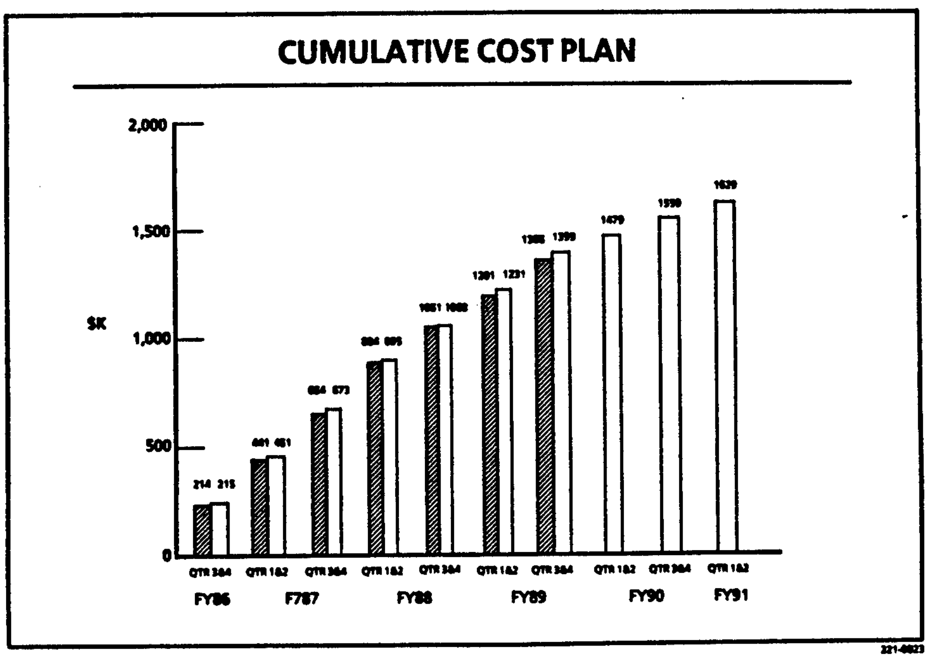

FIGURE 6.1
CUMULATIVE COST PLAN

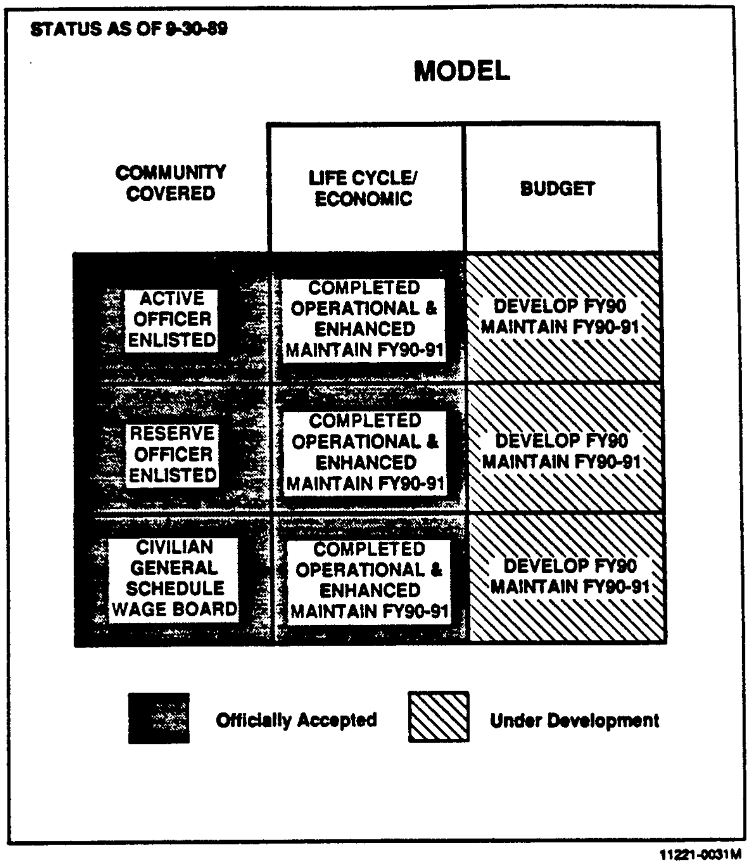

FIGURE 6.1
AMCOS DEVELOPMENT PLAN

7.0 AUTHENTICATION

This semi-annual report is approved.

Donald E. Rose, Jr.
Contractor's Project Director

David K. Horne, Ph.D.
Contracting Officer's
Representative

APPENDIX A
AMCOS MAINTENANCE AND FOLLOW-ON ENHANCEMENTS

A.1 AMCOS MAINTENANCE AND SERVICE

AMCOS has been very successful to date in providing the Army with tools that allow them to estimate future manpower costs. The models we built are current, flexible, user friendly, and proved to be very useful to the Army in several applications. If these models are to retain their usefulness they will need to be maintained on an annual basis. Specifically, the Army will have to update the structured cost data base annually with current cost data and it must be able to modify and update the model's code as necessary to reflect the current policies. The Army must consider how they will maintain the AMCOS models after completion of the contract.

Over the past 42 months, SRA has maintained the AMCOS models. The resources we used each year to perform this function were 3 man-months of effort using at least one programmer proficient in "C". Because of our experience in updating the models' cost data bases, we are not only intimately familiar with the AMCOS models but we are able to update the models with a minimum of problems. An option available to the Army is to have SRA continue the maintenance of the AMCOS models.

A.2 FOLLOW-ON ENHANCEMENTS

The AMCOS models are state of the art analytical tools that have been very helpful for the Army. Even so, technology is constantly improving and there are several areas that could be improved to allow the army users more efficiency, completeness, and flexibility. We have discussed these potential enhancements with the Director of CEAC. The enhancements are summarized below. They reflect the needs that the Army has expressed to us over the life of the contract to date.

A.2.1. User Flexibility

A.2.1.1. Automated Selection of ATRM-159 Cost Elements

At present AMCOS uses only the total variable costs from the ATRM-159 as input to the structured cost data base, but the report contains much more detailed data that is of interest to several users. Some of that data includes the detailed costs for both fixed and variable costs; overhead costs; and information about class size modal grade, etc. What is a fixed cost and what is a variable cost often depends on the nature of the question. A useful enhancement to AMCOS would allow the user to choose the data that is most appropriate to the issue.

A.2.1.2. Expanded PCS Policy Module

At present AMCOS costs PCS moves using a single cost factor for each category of move. This certainly provides reasonable cost estimates for determining PCS costs, but does not provide the degree of flexibility that an enhanced PCS module would provide. The refined module would expand the current cost capability by including additional cost variables. The analyst would then be able to evaluate such policies as SEPOS (senior enlisted positions overseas) levels, numbers of accession moves made overseas, or the numbers of total OCONUS tours in view of a major budget reduction. Expanding the PCS module would require more detailed data than is already available to the Army. We propose that the Army initiate a study to obtain more detailed data on the variables that influence PCS costs. With the new data SRA would be able to develop revised cost estimates that would provide reasonable answers to some of the more difficult PCS questions. By adding this module to the AMCOS budget analysis model, the Army would make the model a much more flexible tool. An additional incentive for developing a more sophisticated model is the current DoD Directive requiring the services to develop options for providing much of this information to a DoD PCS management information system.

A.2.1.3. A Report Writer

Because of the wide variety of applications of applications of AMCOS there is no one standard report format. For that reason a report writer module with a choice of several report formats, including the capability to

tailor the report to specific needs, would be a very useful option. For example, CEAC analysts would be able to print AMCOS output in "P-92" format thereby eliminating the need ti transfer the data from one to the other.

A.2.1.4. Automated Generation of Final Cost Files

The current AMCOS models have default final cost files that must be generated by SRA (or whoever is maintaining the models). These final cost files can be modified by the user, but it is a limited capability. A useful enhancement to the model would be the creation of a shell that would allow the user to automatically rerun selected policy modules. This would make it much easier to generate additional final cost files. This capability makes it much easier for the user to evaluate personnel policy alternatives that affect manpower costs.

A.2.2. Data Completeness

A.2.2.1 Addition of an Accession Supply Module

Under this option, the budget analysis model would include a module that predicts the number of accessions by mental category, for a given market scenario. This methodology would provide a more accurate estimate of the accession requirements. The existing method calculates accessions as the difference between endstrength targets and projected inventory. The use of this method assumes that the manpower pool will fully support accession requirements in terms of both numbers and quality. An accession supply module would eliminate the need to make that assumption and therefore provide the user with a more defensible estimate.

A.2.2.2. ASI, SQI, and NCOES Costs

In the area of training, the current structured cost data base does not include costs for the non-commissioned officer educational system (NCOES). It also does not include the costs to provide specialty training at the sub MOS level. An enhancement to the AMCOS models would be the development of a methodology to spread these costs to the MOS level of detail.

A.2.2.3. Transition Cost Calculator

As new weapon systems phase in and phase out of the army inventory, MOS are constantly changing with the Army retraining personnel to receive the new MOS. A useful enhancement to the models would be the addition of a module that automatically calculates the cost of retraining an individual into the new MOS during the transition of new weapon systems.

A.2.3. Efficiency of the Model

A.2.3.1. Optional Amortization Methods

In a model such as the LCCM where inventory flow is not explicitly modeled there is a problem of how to deal with investment costs that realize a return to the Army throughout the soldier's career. At present the model uses one amortization scheme, but since there is no "right" way to amortize for all situations, alternative schemes could be offered to the user through an enhanced amortization module.

A.2.3.2. Automated MOS-B Module

The Army's MOS-B publication captures the accumulated costs of a soldier from the reception station to the completion of skill level 5 training. It includes bonus costs for enlistment and reenlistment. It is not a useful tool for two reasons. One, the publication is outdated, as the Army has not updated it for several years; two, it is not automated. The structured cost data base already contains most of these costs. A much needed enhancement would be to automate the calculation of the MOS-B costs. This would provide the user with up to date soldier replacement costs quickly.

Manpower and Personnel Policy Research Group

Working Paper MPPRG 90-03

ENLISTED PERSONNEL INVENTORY COST AND COMPENSATION MODEL SEMI-ANNUAL PROGRESS REPORT

DONALD E. ROSE
D. ALTON SMITH

1 MAY 1990

FOR ARI INTERNAL DISTRIBUTION

Approved by:

Curtis L. Gilroy
Chief, Manpower and Personnel Policy Research Group

MANPOWER AND PERSONNEL RESEARCH LABORATORY

U.S. ARMY RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES
5001 Eisenhower Avenue, Alexandria, VA 22333-5600

**ENLISTED PERSONNEL INVENTORY
COST AND COMPENSATION MODEL**

**SEMI-ANNUAL
PROGRESS REPORT**

EPICC MODEL

Prepared for:

Manpower and Personnel
Policy Research Group
U.S. Army Research Institute

Prepared by:

Systems Research and Applications Corporation
2000 North Fifteenth Street
Arlington, Virginia 22201

April 1990

TECHNICAL REPORT

EPICC Semi-Annual Progress Report

Contract Number	MDA903-89-C-0264
Contract Expiration Date	24 September, 1991
Total Dollar Value	$396,876.00
Short Title of Contract Work	EPICC
Author	Donald E. Rose, Jr. D. Alton Smith, Ph.D.
Name of Contractor	Systems Research and Applications (SRA) Corporation
Contractor's Project Manager	Donald E. Rose, Jr.
Phone Number	(703) 558-4700
Contracting Officer's Representative	David K. Horne, Ph.D.
Date of Submission	April 1990

I certify that this product is accurate and consistent with SRA's high standard of quality.

Donald E Rose

Project Manager

4/24/90

Date

I certify that I have acted as the Project QA Official for this product and found it to be consistent with SRA's high standard of quality.

Matthew Black

Project QA Official

4/26/90

Date

1.0 This report is submitted as deliverable 0002AB under contract number MDA903-89-C-0264. The report is organized as follows:

- Section 1 is the report organization
- Section 2 discusses the project activity to date.
- Section 3 deals with problems encountered during the reporting period.
- Section 4 provides an overview of the EPICC model.
- Section 5 is a summary of all briefings, meetings, visits, or seminars, held during the reporting period.
- Section 6 is a summary of the project's fiscal data.

2.0 Project Activity to Date

In September work officially began on the Force Structure Planning Model (FSPM). Since that time all parties have agreed that this project will now be called the Enlisted Personnel Inventory Cost and Compensation (EPICC) Model because it is more descriptive of the purpose of the model. Henceforth all references to this project will be made using the acronym EPICC.

In September we initiated planning for development of the concept paper and initial model prototype. This required putting together an overview briefing of our concept and bringing that briefing to potential users. This became an iterative process as we integrated their suggested changes or improvements. As the concept became more concrete we built a LOTUS spreadsheet model on a reduced scale for the purpose of surfacing design issues. In addition this spreadsheet assisted us in conveying how we would build this model to potential users.

Specific offices that we briefed the concept and spreadsheet to are listed below;

ODCSPER (DAPE-MPA, DAPE-MPE, DAPE-MBF)
ASA(MRA)
OCSA (DACS-PDM)
Army Research Institute (ARI)

In January we completed development of the initial mathematical models that would be used to program the EPICC inventory projection module. The inventory projection module is the core of the Enlisted Personnel Inventory Cost and Compensation Model. Using a projection scenario defined by the

analyst, the module "ages" the baseline enlisted force, determines promotions and accessions, and calculates summary measures describing the projected force. (Appendix A contains a detailed discussion of the mathematical model) Also in January we initiated assessment of the model's data needs and subsequently sent a formal request for the main body of data to DMDC.

The primary activity during the month of February, was the development of file structures, data requirements, and the initiation of programming of the inventory projection model.

3.0 Problems Encountered or Anticipated. Listed below are discussions of two issues surfaced during the design phase of EPICC. There were other problems of lesser importance that will be discussed in greater detail in our design paper to be published in May, 1990.

3.1 Large Memory Requirements. In determining the memory requirements for processing data, we realized that the constraining module in the EPICC model is the inventory projection module. All other modules are automated tools currently being used by the Army with no foreseeable memory problems. Since the model design calls for running each module sequentially, we focused on the data processing requirements of the inventory module.

The Inventory Projection Module of EPICC will initially be broken into three executables: 1) setting up the projection scenario, 2) running the force projection, and 3) displaying the results. The main advantage of this approach is that the RAM needed for the windowing package can be isolated in executables 1) and 3). The executables can perhaps be joined in the future as memory permits. We expect that the windowing package will require no more than 150k bytes of RAM.

Under this plan the executable to run the force projection requires the most careful planning with respect to memory. We expect this executable to use no more than 300k bytes of RAM. When considering that windowing uses no more than 150k at any given time, we will fall well within the 640k bytes RAM common to most machines.

3.2. Small Cell Sizes. As the sample of soldiers used to calculate a particular continuation rate decreases, the standard error of that rate and, therefore, the standard error of the projected inventories based on that rate increase. In the limit, rates for cells with zero members cannot be estimated. One response to small cell sizes is to pool soldiers across inventories, years of service, skills, or fiscal years and calculate rates based on these aggregated cells. This, however, can introduce bias into the estimated rates because the soldiers used to calculate a particular rate no longer have the same characteristics. In general, there is a tradeoff between reducing the variance of an estimated rate and increasing the bias.

We propose the following procedure for dealing with the small cell size problem in the EPICC. First, we will identify those continuation rates based on cell sizes of less than 25 soldiers. Below this level, the confidence interval for predictions based on these continuation rates becomes unacceptably large. Then, we will combine the soldiers in each of these cells

with soldiers in the same YOS, race, sex, and quality category in a "related" occupation and recalculate the continuation rates. The pooled rates will replace the rates actually observed in the small-sample cells.

Previous research has shown that demographic and YOS differences in reenlistment rates are substantial, so that pooling across these characteristics would significantly bias the rates. Pooling across fiscal years is also not desirable because it obscures the effects of recent personnel policy changes on continuation rates. The best way to pool, therefore, seems to be across similar occupations, such as within the combat arms skills. We can use standard statistical tests to choose the occupations that are best for pooling.

4.0. Overview of the EPICC Model

EPICC models the Army enlisted force at the all Army and CMF level. It captures the salient aspects of both the manpower and personnel systems. It allows analysts to model pay and personnel policies in order to forecast their inventory and budget effects as the force evolves over time and persists in a steady-state. As noted below, there are three primary modules that comprise EPICC.

- The Inventory Projection Module, based on Markov transition probabilities, will project the inventory of the relevant occupational groups as a function of demographic and quality characteristics, and personnel system variables.
  - The module can be driven by an end-strength goal, or the supply of accessions, based on the user's choice;
  - The Promotion sub-module will model the effects of a vacancy-driven promotion system, but will also allow the analyst to examine the effects of alternative rule-based systems including alternative time-in-grade, time-in-service assumptions; and
  - The Personnel Planning sub-module will allow the analyst to examine the effects of changes in key policy variables, such as reenlistment eligibility rates, enlistment and reenlistment contract mix, and "early out" policies.

- The Compensation and Retention Module allows the analyst to estimate the effect of alternative compensation and bonus policies on retention.
  - The analyst may specify and analyze a scenario for active duty soldiers that includes the pay of soldiers, bonus levels at zones A, B and C, the increase in the pay of civilians relevant to soldiers, and the path of the civilian unemployment rate; and

- Targeted pay raises, the effectiveness of reenlistment bonuses, and the retention effects of changes to the retirement system may be considered.

- The Cost Module provides the analyst with an immediate estimate of the cost of the inventory, and the compensation and personnel policies analyzed, for each projection year.

  - The module will include the costs of recruiting, training and sustaining the inventory;

  - It will allow the analyst to consider the cost implications of key policies such as the timing of training, the average PCS tour length, and alternative quality mixes of recruits; and

  - It will interface with the Compensation Module, so that the cost implications of alternative pay raise and bonuses scenarios considered in the Compensation Module will be immediately reflected in the cost data base.

These three integrated components form a comprehensive system for (1)projecting the enlisted force over time under alternative scenarios, (2)estimating the effects of changes in manpower requirements, and (3)evaluating the effects of alternative compensation and personnel policies on force manning and cost. For example, the EPICC Model will allow the analyst to consider not only the primary "impact" effects of policy changes, such as the increased retention associated with higher Zone A reenlistment bonuses, but the ripple effects on accessions, recruiting costs, force sustainment costs, and promotion times.

5.0. Summary of all briefings, meetings, visits, or seminars

5.1. October 25, 1989, Dr. Smith and Mr. Rose, SRA, briefed LTC Martell, ODCSPER (DAPE-MPA) on the EPICC concept. As a result of that meeting LTC Martell suggested several offices that should be briefed and solicited for comments.

5.2. November 1, 1989, Dr. Smith and Mr. Rose, SRA, visited with representatives from the ODCSPER Staff (DAPE-MPE, DAPE-MPA) to discuss the EPICC concept. The major concern expressed at this meeting was for an official sponsor. Dr. Horne indicated that a briefing to BG Stroup was planned for November 3, 1990. He expects BG Stroup to pick up sponsorship at that briefing.

5.3. November 9, 1989, Dr. Smith and Mr Rose, SRA met with representatives of the ODCSPER Staff (DAPE-MBF) to discuss the EPICC concept. The major concern expressed at this meeting was the perception that EPICC could replace ELIM-COMPLIP. We assured all present that EPICC, as a tool for analysis, would

compliment the capabilities of ELIM-COMPLIP.

5.4. December 6, 1989, Dr. Smith and Mr. Rose visited MAJ Scribner, Army PA&E, to discuss the EPICC concept. There were no major concerns with the material presented.

5.5. February 1, 1990, Dr. Smith and Mr. Rose met with COL Thie, ASA(M&RA), to discuss the EPICC concept. COL Thie was very receptive and added that he could use the model right now. He indicated that as soon as the model was running with meaningful data he would like to give the model to the Deputy Asst Secretary of the Army for Military Personnel Management to review.

5.6. March 9, 1990, the SRA EPICC team visited ARI to brief the ARI Econ Team. Key members of ARI in attendance were, Dr. Gilroy, Dr. Horne, Dr. Nord, and Dr. Tinney. The concept, as presented, was well received.

6.0. Fiscal Report

6.1 Table 1 displays in tabular form the professional man-days expended by task (includes cumulative man-days, remaining man-days). Table 2 displays in tabular form the actual versus planned expenditures, and remaining funds (includes projected costs for the remainder of the contract). Note that projected expenditures reflect an accelerated schedule as outlined in our proposal.

6.2 Figure 1 graphically displays the actual costs expended during the reporting period and the projected costs for the remainder of the contract. Figure 2 graphically compares actual costs with planned for the reporting period.

TABLE 1: Professional Man-Days

Employee Name	Task 1[1]	Task 2[2]	Task 3[3]	Cumulative
Black, Matthew			3.6	3.6
Chin, Carol			1.7	1.7
Eichers, Danny		26.4		26.4
Greg, Thomas			.6	0.6
Hogan, Paul[4]	2.5			2.5
Lewis, Beth	45.0		15.5	55.5
Rose, Donald	10.5	15.1	23.0	48.6
Smith, Dave	35.2		21.3	56.5
Slywester, Stephen			9.7	9.7
Villa, Christine			.7	0.7
Wagoner, Raelene			.4	0.4
Support			5.2	5.2
Total Days Used	93.2	41.5	81.7	211.4
Days Remaining as of March 1990				750.6

[1] Task 1 is to develop an enlisted inventory projection model

[2] Task 2 is to develop a cost interface with the AMCOS cost data base

[3] Task 3 is to integrate the inventory projection model, the cost interface, and the Army Reenlistment Model into a PC based prototype

[4] Includes hours charged as a subcontractor.

TABLE 2: Project Costs

March, 1990

Month	Planned	Actual	Cum	Remaining
9/89	0	0	0	368156
10/89	12829	14397	14397	353759
11/89	18220	13284	27681	340475
12/89	19805	15038	42719	325437
1/90	21600	17969	60688	307468
2/90	22786	15748	76436	291720
3/90	26842	23040	99476	268680
4/90	24256			
5/90	27706			
6/90	26054			
7/90	27358			
8/90	36601			
9/90	23477			
10/90	18766			
11/90	18766			
12/90	15818			
1/91	15818			
2/91	8818			
3/91	7000			

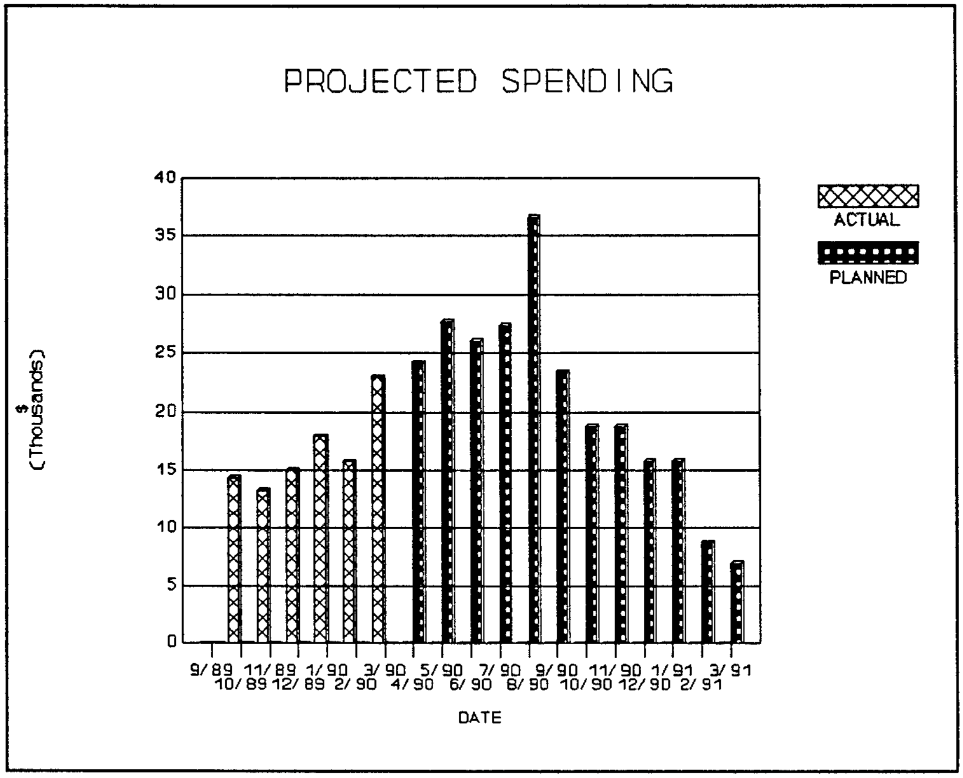

Figure 1 - Projected Spending

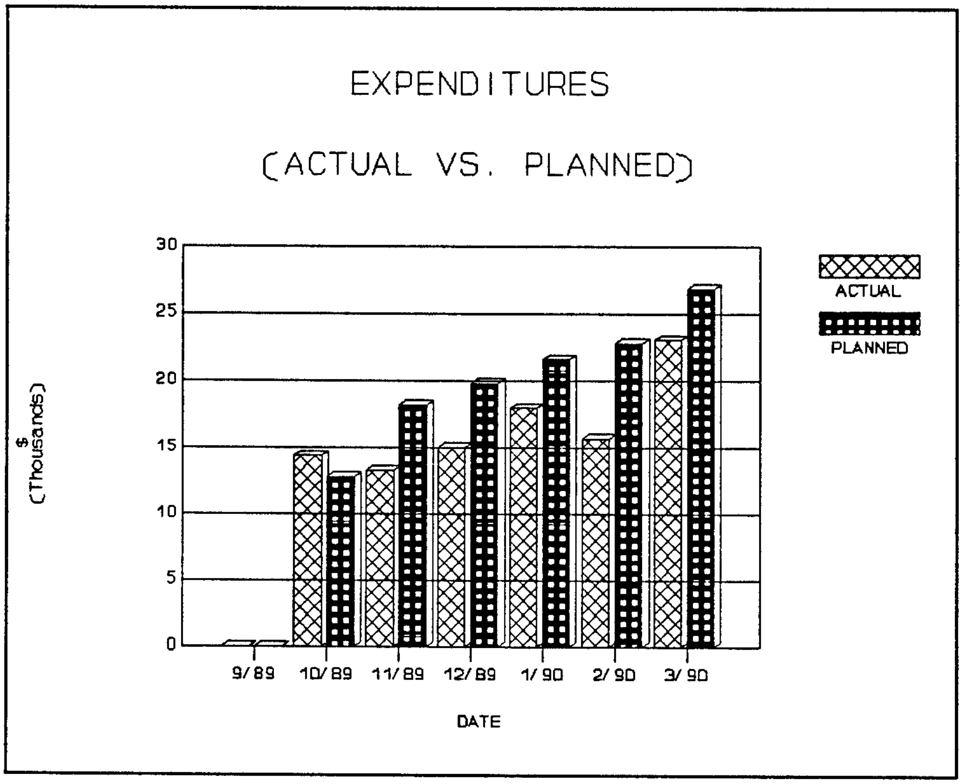

Figure 2 - EPICC Expenditures

Working Paper MPPRG 84-~~12~~ 17

MATCHING PEOPLE WITH JOBS: THE DEVELOPMENT OF A NEW ARMY PERSONNEL ALLOCATION SYSTEM

By: Edward J. Schmitz

August 1984

U.S. Army Research Institute
for the Behavioral and Social Sciences
5001 Eisenhower Avenue, Alexandria VA 22333

MATCHING PEOPLE WITH JOBS: THE DEVELOPMENT OF A NEW ARMY PERSONNEL ALLOCATION SYSTEM

OVERVIEW

This paper describes the development of the new EPAS system for matching people with occupations for the Army. The important factors and policies affecting the personnel decisions, the design of the system, and expected benefits form the new system are discussed.

A comprehensive research program is now underway at the U.S. Army Research Institute to improve the selection, classification, and allocation of Army personnel. An important part of this program is the development of the Enlisted Personnel Allocation System (EPAS). EPAS will improve personnel management by achieving a better match between Army requirements and personnel capabilities.

The Army is confronted today with the enormous task of balancing the supply of over 300,000 applicants per year against the different demands of 250 entry level occupations. Recent improvements in ADP and operations research capabilities have made it possible to solve complex allocation problems quickly and cheaply. The EPAS project marks a breakthrough in the application of technology to personnel management.

By the end of the decade, EPAS will support job decisions for new applicants, reenlistees, prior service personnel, and people being retrained. The largest of these categories, and the most difficult for which to plan, is the one for applicants without prior service. Therefore, the system for non-prior service applicants is being developed first and will be available for field tests during FY85.

This paper describes what EPAS is and how it is being developed. The first section provides background on the enlistment process, current problems, and the interrelated research efforts that will affect EPAS. The second section describes the technical approach being used to improve Army's allocation. The last section describes the benefits that will result from successful EPAS development.

BACKGROUND

The Enlistment Process

Every year over 300,000 people apply to join the Army. Once an applicant qualifies on the Armed Services Vocational Aptitude Battery (ASVAB) and passes the physical examination, he meets with a guidance counselor to sign an enlistment contract. The applicant then enters the delayed entry program (DEP) until it is time to begin training. Figure 1 illustrates the major steps in the enlistment process.

Figure 1 about here

The selection of the military occupational specialty (MOS) is a key decision in the enlistment process. The MOS determines many aspects of the individual's tour. It affects where he trains, whether there is an enlistment bonus, the contract length, and where the tour will be served. The Army guarantees the individual the training of his choice. However, there are over

250 different MOS for initial training, and the typical young applicant has little knowledge about these jobs.

The Army also has its list of concerns for the selection process. The first priority is to fill its MOS requirements. The jobs most in demand by applicants are not necessarily the ones the Army needs filled. Next, it would like to distribute training activities relatively evenly over the year, rather than have the training base undergo costly and inefficient fluctuations in workload. Also, the Army wants good people. The Army needs bright, educated young people to put into MOS where they can become excellent soldiers.

The Army has several pieces of information about the applicants that it can use to evaluate MOS allocation decisions. These include:

- Armed Forces Qualifications Test (AFQT) Scores
- Aptitude area composite scores
- Physical profile
- Availability and preferences
- Education
- Numbers and characteristics of future applicants

The AFQT, computed from the ASVAB, is a test to determine whether an individual is eligible to enlist. AFQT scores are also used to determine eligibility for bonuses and the Army College Fund.

Aptitude area composite scores, also computed from the ASVAB, are used for determining eligibility for specific kinds of training. These scores also serve as a good predictor of post-training job performance (Hanser & Grafton, 1983).

The physical profile, together with gender, is one of the determinants of what jobs an individual would be permitted to perform. For example, many MOS require an individual to pass eyesight or physical strength standards.

Army applicants usually indicate when they want to enter the service and the kind of training they wish to receive. Their preferences may largely determine the length of tour, the location where they serve, and whether they are eligible for a bonus. Because applicants have limited information about the large number of options available, and many of these options are part of package deals, a complicated set of choices must be evaluated quickly.

Education is important as both a general and specific factor. The more education individuals have, the more likely they are to complete their enlistment tour, and the fewer disciplinary problems they are likely to present. Specific courses, such as trigonometry, algebra, or typing also may be a prerequisite for a particular MOS.

A final type of information that could be used for analyzing MOS decisions is the numbers and characteristics of future applicants. The Army needs to

evaluate individuals not just in terms of how they compare to minimum standards, but how they compare to actual or expected candidates for an MOS.

Substantial work has been done on projecting the numbers of total accessions the services will receive. Economic conditions and compensation have been shown to be significant factors (Dale and Gilroy, 1983) and recent research is also taking recruiting goals into account. While gross numbers of projected accessions are important, they are inadequate, even when broken down by AFQT category. Previous research by several analysts has shown that information is needed not just on broad categories of ability, but on the tradeoffs of assigning an individual to different kinds of training (Ward, 1978; Hunter and Schmidt, 1982; Schmitz and Nelson, 1982). An individual who is equally good at everything has a different set of job assignment possibilities from an individual who has mechanical aptitude but no other outstanding talent.

Opportunities for Improvement

The Army's approach to matching applicants with MOS has changed in the last several years. With the advent of the volunteer force, the Army began to promise skill training as an enlistment incentive. There was no longer the opportunity to wait until basic training was complete before assigning MOS training seats. The REQUEST system was constructed to permit real time training seat scheduling. However, REQUEST was only able to check for minimum qualifications, and the lists of training vacancies were quota driven.

Recently, the Army has upgraded the person-MOS decision algorithm within the REQUEST system. The current algorithm is structured along the lines of the decision algorithm developed by the Air Force (Ward, 1979). It provides the capability to allocate MOS based upon such attributes as AFQT category and Army requirements, and to control the quality mix of individuals into MOS.

While REQUEST has improved MOS allocation, there is still substantial room for improvement. Recommended MOS assignments are still largely based on filling the training seats for unpopular or hard-to-fill MOS. This concentration on filling near-term requirements sometimes results in candidates being trained in MOS for which they have poor aptitude. While REQUEST does guarantee that a candidate meets a minimum standard, the system cannot, however, identify if he has greater aptitude for another MOS that is also in demand, or if he may be best utilized in his second-best skill because he is almost as good in that area. This latter feature would allow another person who is not so broadly talented to occupy the other position. The current system does not attempt to assess the trade-offs among assignments or allocate people based upon the overall value of that assignment to the Army.

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[1] Recruiters are given specific goals as to the number of contracts to be recruited by education, AFQT category, and sex. This goals have a major influence on the mix of individuals recruited.

The REQUEST system does not have the capability to forecast shortages and excesses of Army applicants. Incorporating such a forecasting procedure would permit USAREC to reject minimally qualified people for an MOS when higher quality ones can be expected to apply.

Any short-sighted initial enlistment policy can lead to later problems in personnel management. For example, it is important to retain sufficient numbers of trained people who can become the NCO leadership. While some future imbalances can be corrected with reenlistment bonuses and other policies, it would be preferable to use the initial enlistment distribution to prevent these problems from occurring.

The problems listed above exist in what has been a relatively good recruiting environment. Unemployment has been high and military pay has been increasing and both these factors increase enlistments (Daula and Fagan, 1982; Dale and Gilroy, 1983). However, unemployment is declining and so is pay relative to the civilian sector. The numbers of males between the ages of 17 and 21 will also decline substantially over the next decade due to the low birth rates during the 1960s and early 1970s.

The demand for people is also changing. The Army of the future will contain more support positions and fewer combat positions. This increase in requirements for mechanics, electronic technicians, and equipment repairers has implications for the kinds of people recruited today to become the senior enlisted personnel of the future.

No one can predict what the recruiting environment will be like in the future. However, it can be expected to change substantially from the current one. Adapting enlistment allocation decisions quickly to the recruiting environment requires a system that performs aggregate demand and supply analyses.

Other Army changes that will affect the environment in which EPAS will operate are the Joint Optical Information Network (JOIN) and the selection and classification research currently being performed by ARI. JOIN will provide career counseling information through the use of automated videodisc technology. Applicants will be shown video presentations of different MOS. More fundamental changes in the allocation process will likely result from ARI's selection and classification research. New predictor tests and performance measures, such as psychomotor and perceptual tests, are being developed and should greatly improve the quantity and quality of information available for allocation decision making. The new performance prediction data will include both MOS-specific and Army-wide success measures. This poses several decision analysis issues, such as how to compare performance levels between MOS and assess general soldiering skills. The EPAS allocation system will need to be flexible, so that it can readily incorporate new kinds of measures and tradeoff analyses.

Figure 2 summarizes the current automated systems which support Army enlistment and MOS assignment, and the next generation of automated support.

Figure 2 about here

THE TECHNICAL APPROACH

EPAS is being designed to achieve effective and efficient allocation of personnel to MOS. Figure 3 illustrates the system construct. There are four principal modules for EPAS:

- The Requirements Module
- The Availability Module
- The Horizon Planning Module (HPM)
- The Sequential Classification Module (SCM)

Figure 3 about here

Each of the modules is discussed in detail below.

THE REQUIREMENTS MODULE

The Requirements Module will provide EPAS with the schedule of training classes and the aggregate MOS training goals. The information will be obtained from the Army Training Requirements and Resource System (ATRRS).

The Requirements Module is largely basic input for EPAS. However, there are several issues that need to be resolved through research. One is the length of the planning horizon. At a minimum, the Requirements Module will need to deal with the length of the delayed entry program DEP, or 1 year. It may be useful to extend the horizon out as far as 5 years for policy analysis.

A second factor that needs to be determined is what flexibility exists in meeting class size goals. The amount of variability that can be tolerated in filling training classes should be an important consideration for scheduling enlistment contracts.

The Availability Module

The Availability Module will provide EPAS with forecasts of the number and types of people who will probably be available to the Army over the planning horizon.

These forecasts are different from traditional current forecasts of contracts. The projections will be aggregated into groups (allocation categories), and they also must be in appropriate detail for MOS allocation. AFQT scores or categories are insufficient. The combinations or clusters of aptitude scores will need to be estimated based upon score distributions that have occurred in recent years. For example, individuals with equal aptitude for all MOS would likely be allocated differently from individuals with a high aptitude in electronics, but average aptitude for other MOS.

The contract availability projections for EPAS will need to reflect Army recruiting missions, seasonal and holiday effects, short-term trends, and selected policy variables. USAREC recruiting missions, in use as goals since FY81, have been the major factor in determining the numbers and types of Army contracts (Moore, McWhite, Schmitz, and Allen, 1983). Seasonal and holiday effects, combined with short term trends are important fluctuations need to be accounted for in EPAS. Sustained short term trends may also provide an indication of significant changes in the recruiting environment.

Finally, the EPAS supply module should give policy analysts personnel policy simulation capability. It would be desirable, for example, to perform "what if" exercises, such as evaluating the impact of bonus policy changes on the number and types of applicants.

The major research issues for the personnel availability module are presently being investigated at ARI. The time periods and the allocation categories need to be determined. Either recruiting missions need to be converted to allocation categories or allocation categories will be projected independently. Holiday and seasonal effects need to be quantified. An approach for projecting short-term mission achievement also needs to be found.

The Horizon Planning Module

The HPM will compute an optimal allocation strategy for assigning allocation categories to MOS. The HPM will use linear optimization to develop an ordered list of MOS for each allocation category and for each time period. The HPM will also provide information on selected management alternatives and measures of their value in different recruiting environments.

Several important research questions will need to be resolved in the near future to develop the HPM. These include optimization methodologies, defining decision variables and problem dimensions, and estimating key parameters for making tradeoffs. These problems are interrelated, so they cannot be solved independently.

For example, one problem is defining the key variables within the HPM. These are likely to include predicted MOS performance, training costs, attrition, non-commissioned officer potential, and maintaining a high probability of meeting requirements. These factors will influence the size of the optimization problem and the solution methodology. Also, the way Army goal achievements are to be measured will determine what precision is required for parameters.

The HPM has excellent potential for assessing alternative recruiting policies. It could, for example, examine the impact of changing recruiting mission goals, alternative delayed entry policies, modified MOS class schedules, or changes in the recruiting market. Furthermore, policies could be evaluated against meaningful operational measures, such as projected MOS performance, attrition, retention, cost, or training class fill.

The Sequential Classification Module

The SCM will provide Army guidance counselors with MOS recommendations for each prospective enlistee. In contrast to the HPM, which deals in aggregate personnel categories, the SCM will make recommendations for the individual.

SCM recommendations will be affected by the output of the HPM. The HPM will account for supply and demand fluctuations so that minimally qualified applicants will be discouraged from certain MOS, thus reserving training seats for expected high aptitude people. This approach will differ from that used by the Navy in the CLASP system and by the Air Force in the PROMIS system where decisions on MOS were made without the benefit of overall planning guidance. (Ward, 1979).

The following analogy may be helpful in understanding the the HPM and SCM: The HPM is like an investment outlook that includes short- and long-term recommendations for buying and selling stocks. The SCM is like the account executive who interprets the forecast in light of the investment goals of a specific client.

In much the same way, HPM will recommend aggregate (by allocation categories) recruiting strategies to the SCM. The SCM will modify this information with the specific experiences, capabilities, and applicant preferences to recommend beneficial MOS classifications.

There are a number of research issues that will need to be resolved to develop the SCM. These include:

- Information transfer: What HPM information should the SCM use in its decision functions?

- MOS class fill: What SCM real-time adjustments of school training seat priorities will be needed?

- Accounting for individual-specific training, experience, and interests: How do these factors affect an applicant's performance in an MOS?

- Contract negotiation strategy: Based upon an applicant's MOS potential, what is the Army's degree of willingness to accommodate an individual's preference? Some candidates may perform equally well many different MOS; other candidates may be much more valuable as performers in some specific MOS.

EPAS Development Strategy

The strategy for developing EPAS is evolutionary as well as revolutionary: emphasis is being placed on developing and testing experimental versions of the entire system as early as possible rather than attempting to refine specific modules. Only in this way can the effectiveness of different approaches or formulations be evaluated. As research progresses and modules become more refined, they will be easily updated within the operational system.

Figure 4 illustrates the milestone schedule for EPAS development. The steps include:

Insert Figure 4 about here

- o July 1983 - Experimental SCM. This X-SCM incorporated our best estimate of the functions needed for an Army SCM. For comparison purposes, we also developed operating models of PROMIS and the REQUEST MOS Match Modules.

- o September 1983 - Experimental HPM. ThiS X-HPM was restricted to only about a dozen MOS and a 1-year planning horizon. Its purpose is to provide characteristics of various objective functions and constraints.

- o October 1983 - Demonstration of the Availability Module. This module demonstrated our capability to develop long-term supply forecasts suitable for use by the HPM.

- o February 1984 - Demonstration of an Experimental EPAS. This demonstration will incorporate all the EPAS modules but will be limited to about 30 MOS. The purpose is to develop a test bed for evaluation of the modules without being overcome by the data detail and problem size required to incorporate about 250 entry-level MOS.

- o March 1985 - Prototype EPAS. This EPAS will incorporate all MOS and be suitable for evaluation by USAREC.

BENEFITS

The development of the EPAS is a long-term effort involving the commitment of substantial government and contracting resources. In order to justify these costs EPAS will need to demonstrate substantive improvements in the personnel allocation process. The benefits from EPAS are likely to be:

- o Improved soldier performance
- o Improved recruiting efficiency
- o Better personnel management
- o New policy analysis capabilities

Improved soldier performance should result from a better match between a recruit's capabilities and the job's requirements. Substantial improvements are possible today by making better use of existing applicant data (Schmitz and Nelson, 1982). Even greater improvements will be possible when the new performance predictor tests and measures are developed.

Recruiting efficiency can also be improved. Recent research has found that nearly half of the high-quality Army applicants change their minds and do not sign contracts (Schmitz and Nelson, 1983). EPAS would improve the probability these individuals would sign by reserving desirable and challenging MOS for them.

Management of the personnel pipeline will also improve. The MOS allocation decision would take into account such factors as training attrition and reenlistment potential. For example, a reduction in the first-term attrition rate by 10%, resulting in cost savings in excess of $25 million annually, is a likely benefit in this area.

EPAS will provide decision makers in DCSPER, USAREC, and MILPERCEN with new policy analysis capabilities. Recruiting goals, economic effects, compensation and bonuses, and other factors can be pretested by using EPAS. The complex interactions of various hypothetical actions can be simulated prior to implementation. Furthermore, EPAS will be able to translate the impact of possible actions into meaningful cost and performance measures.

All these desirable capabilities will be produced by EPAS in the long run. In the meantime, the Army continues to allocate over 500 people a day to MOS and to make decisions on recruiting and personnel requirements and costs. EPAS will therefore produce many intermediate research products for immediate application. These products will also stimulate feedback that will further improve the design of the system.

Finally, EPAS will produce scientific benefits. Since the approach expands beyond what the Navy and Air Force are currently using, it is likely that other services will benefit also. A better understanding of the interaction of organization and individual decision making will be developed. New operations research technologies will be created. The Army is developing a new analytical resource as an well as an operational system through the EPAS integration of social science with operations research.

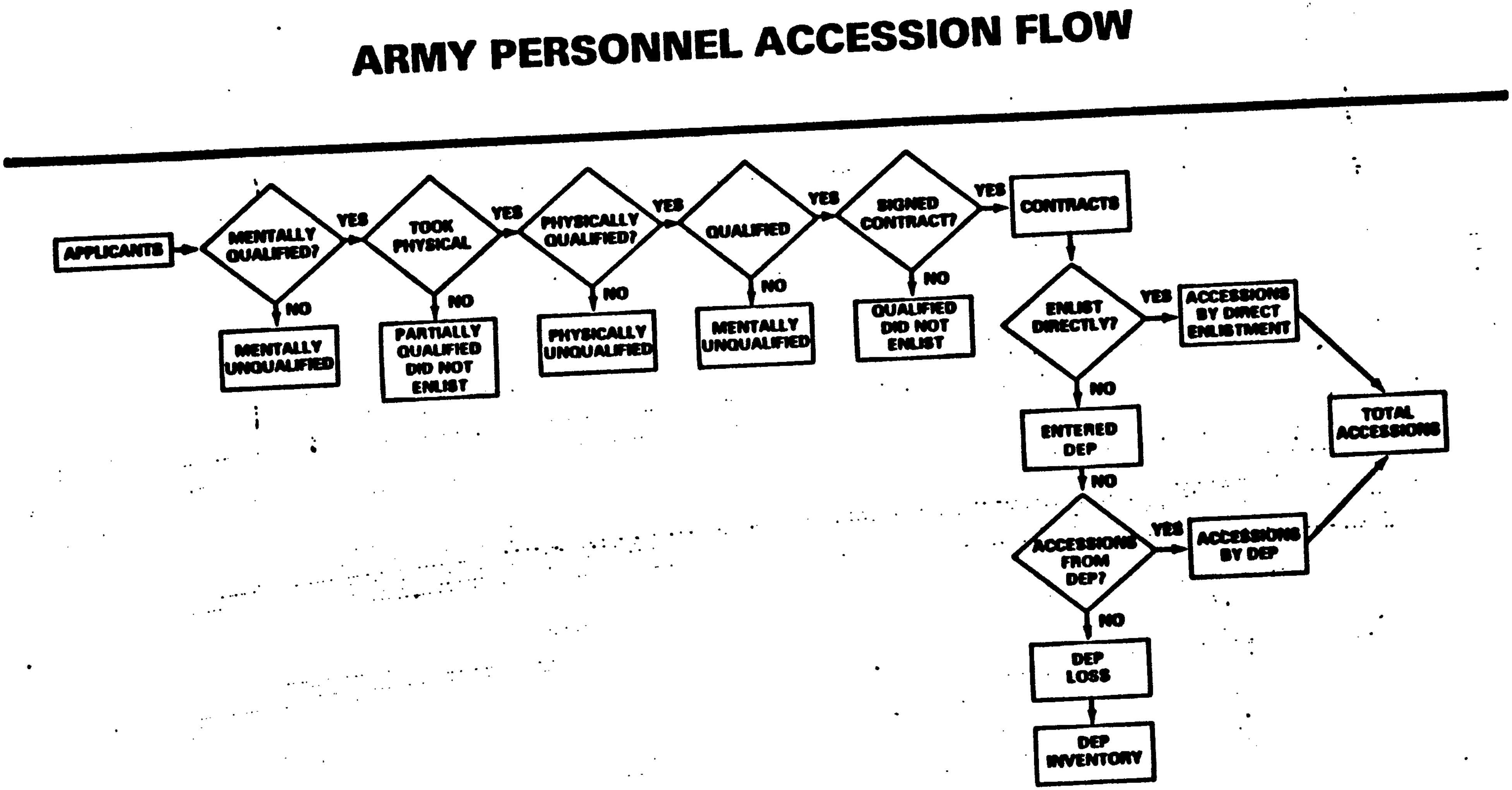
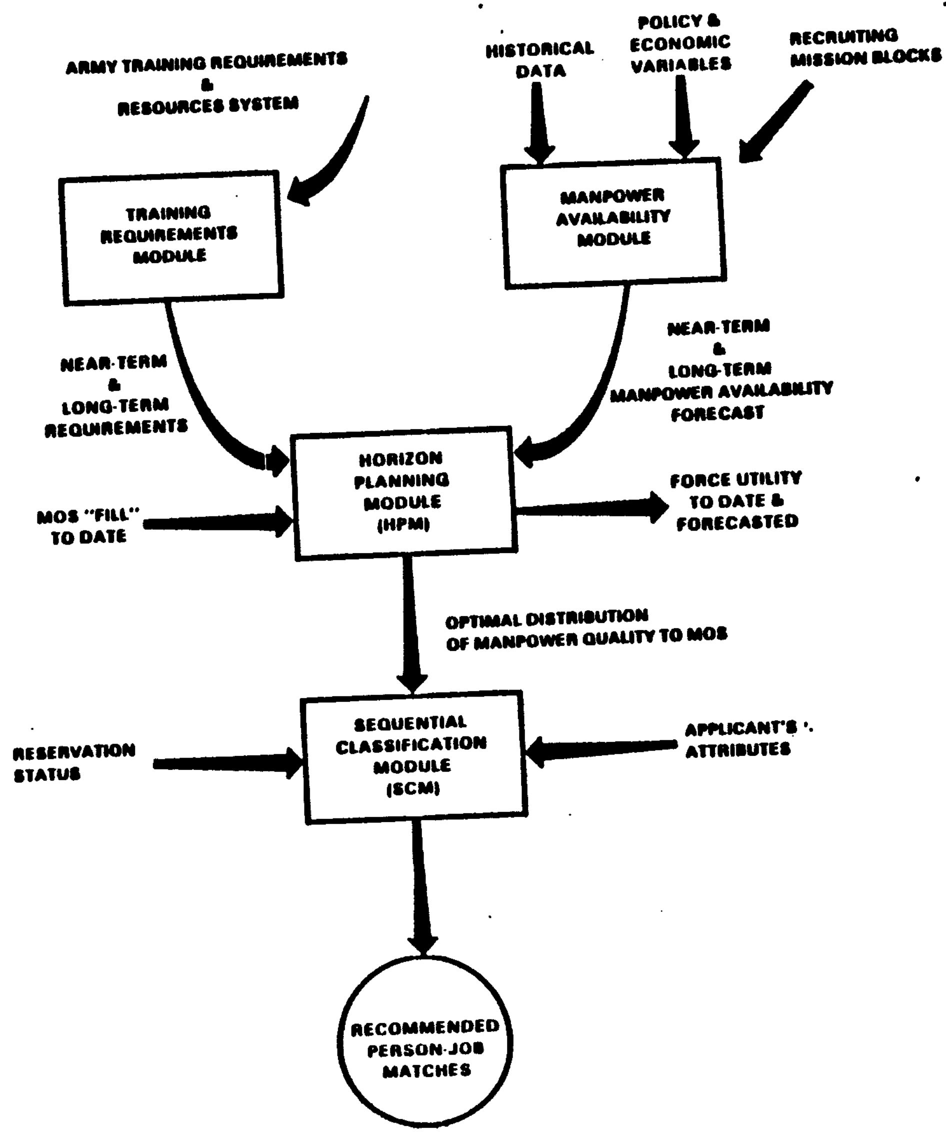


Figure 1. Army Personnel Accession Flow

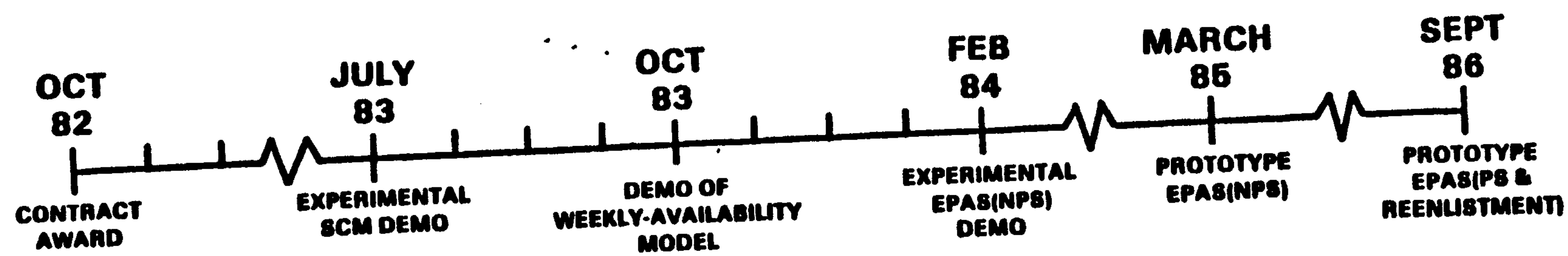
ENLISTED PERSONNEL ALLOCATION SYSTEM



CAREER COUNSELING	**JOIN** • Video presentation of MOS • Adaptive Screening Tests	**JOIN** • Enhanced Data Collection • Interest Inventory • General Career Guidance
MOS SELECTION	**REQUEST** • MOS Prerequisites • MOS Quality Distribution • Real-Time Reservations	**EPAS** • New Classification Tests • New Performance/Cost Measures • Applicant Forecasts • Aggregate Planning • Policy Analysis

Figure 2. Automated Systems Supporting Enlistment

MAJOR EPAS MILESTONES



MAJOR EPAS MILESTONES

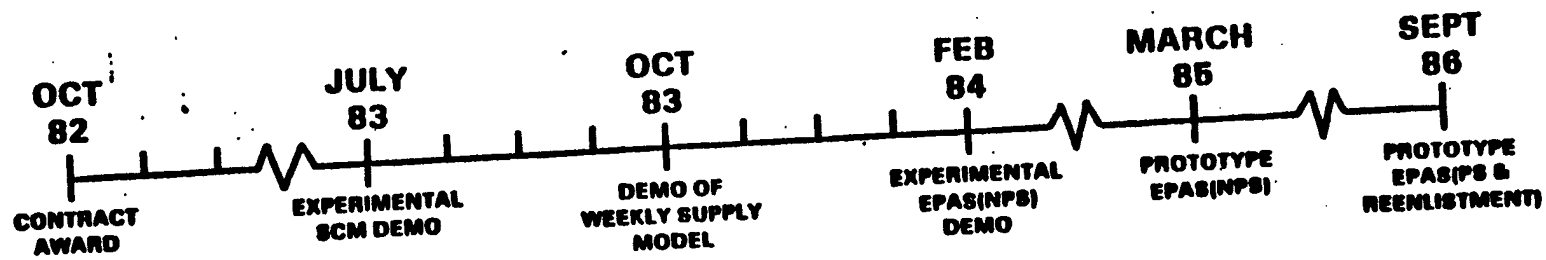


Figure 4. Major EPAS Milestones

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Working Paper

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THE IMPACT OF THE NEW G.I. BILL ON ENLISTMENTS

Edward J. Schmitz

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REVIEWED BY: Timothy W. Elig

APPROVED BY: Curtis L. Gilroy

U.S. Army Research Institute
for the Behavioral and Social Sciences
5001 Eisenhower Avenue, Alexandria VA 22333

THE IMPACT OF THE NEW GI BILL ON ENLISTMENTS

In July 1985 the New G I Bill was implemented. The basic educational benefits associated with military enlistment rose from $5,400 to $9,600 and the soldier's contribution decreased from $2,700 to $1,200.

This paper discusses the impact of this change on enlistments. Estimates are made of the gain in terms of quality enlistments (I-IIIA graduate males) that would be expected based upon previously derived relationships between benefits and enlistments.

Previous Estimates of Effects for Education Incentives

There has been considerable recent research on the impact of educational benefits on enlistments. Nelson (1986) estimated the loss of the old GI Bill resulted in a decline of 7.5% to 21% in quality enlistments for the Department of Defense. Up to half of the drop in quality enlistments that occurred during the late 1970s may be attributable to the reduction of educational benefits.

Three recent analyses provide recent estimates of the impact of educational benefits on enlistments. These are:

- Congressional Budget Office (1982)
- Fernandez (1982)
- Brown (1985)

The CBO study used a simulation model to project the impact of different educational benefit levels on quality Army enlistments. Educational benefits were converted into their present value pay equivalent and used estimates of basic pay elasticities to project the percentage change in enlistments.

Fernandez evaluated the enlistment effects of the FY 1981 Educational Assistance Test Program. He found that increased benefit kickers for the Army would increase enlistments by 9.1 percent without reducing enlistments for other services. This effect was 2.3 times the enlistment effect that might have been predicted from the CBO model. The results of this experiment led to the implementation of The Army College Fund in FY 1982.

Brown (1985) examined enlistment patterns from 1975 through 1982. Using the CBO valuations of different educational benefit packages, he tested the hypothesis that educational benefits were valued the same as their equivalent in pay. He found in fact that they were associated with much greater enlistment effects than pay; he estimated they could be 9.9 times as strong as their pay equivalent.

There is also evidence that increasing the contributions for educational benefit participation would negatively impact on enlistment. A recent survey of new Army recruits (Benedict et al. 1986) found participation in the educational benefit program of New GI Bill and Army College Fund would decrease by at least 16 percent and perhaps as much as 47 percent if contribution levels were increased. It is likely that some portion of those would not simply stop participating but would also fail to enlist if contribution requirements were raised.

Estimates of the impact of the New GI Bill

The impact of educational benefits on quality enlistments is likely to be greater than a similar change in basic pay. To estimate the pay equivalent of a $4,200 loss in future educational benefits (a reduction in the government's contribution from $9,600 to $5,400) the CBO (1982) study on educational

benefits provides some benchmarks. The discounted value of the basic VEAP benefits at the point of enlistment were estimated as ranging from $90 to $770, depending on whether one makes conservative or generous estimates of benefit usage. (The CBO does not report the discount rate used in their analysis. It is likely that one would use a lower discount rate today than in 1981).

However, the analyses performed by Fernandez and Brown would have both estimated a much larger enlistment effect. Fernandez would have estimated an enlistment increase of 2.6 percent due to the replacement of VEAP with the New GI Bill. Brown's benefit elasticity would have estimated 11.4 percent additional quality enlistments. Thus, the impact of increased educational benefits for FY86 would have been estimated to be between 1600 and 6900 additional high quality male recruits.

Historical econometric analyses of educational programs provide considerable evidence that benefits are valued greater than their cash equivalent. Furthermore, these estimates can be viewed as conservative since they do not take into account the reduction in contributions, and the advertising impact of the term "GI Bill". Both of these factors could be expected to generate additional positive enlistment impacts.

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Working Paper MPPRG #14

EDUCATIONAL BENEFITS

AND

MANPOWER PLANNING

EDWARD J. SCHMITZ

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REVIEWED BY: David K Horne

APPROVED BY:

U.S. Army Research Institute
for the Behavioral and Social Sciences
5001 Eisenhower Avenue, Alexandria VA 22333

INTRODUCTION

Previous research on educational benefits has focused on their effectiveness as an enlistment incentive. However, educational benefits could also impact on other areas important for manpower planning. Educational benefits would be expected to affect both choice of enlistment term and reenlistment behavior due to the economic incentives they provide. Furthermore, in-service attrition may vary due to the behavioral motivation provided by educational benefits. Individuals enlisting to receive educational benefits may be more motivated to put up with the immediate hardships of military life, or they may be more likely to attrit early if they find the military difficult.

This paper provides a summary of the differences between four educational benefit programs that were tested in FY81. Programs are compared as to their effects on the enlistment term, attrition, and reenlistment behavior of quality recruits (graduates scoring in Test Categories I-IIIA). While no statistical explanatory model is provided, the results indicate that educational benefit programs are likely to be associated with substantive differences beyond the enlistment point, especially with reenlistment behavior.

COMPARING PROGRAMS

FY 81 saw a major experiment on education benefits. Four different educational benefit programs were tested in different geographic areas. These were:

<u>Super VEAP</u>: required contributions of up to \$2,700, with kickers of \$2,000 to \$6,000.

<u>Ultra VEAP (Army College Fund)</u>: required contributions of up to \$2,700, with kickers of \$8,000 to \$12,000.

<u>Noncontributory VEAP</u>: required no contributions, and offered kickers of up to \$6,000.

Tuition/Stipend Program: no contributions with total benefits ranging from $7,800 to $15,600; option to cash out or transfer benefits upon reenlistment.

The major quantitative impacts of educational benefits on manpower should occur in the following areas:

- o enlistments
- o enlistment term
- o first-term attrition
- o reenlistment

The enlistment effect was analyzed in detail by Fernandez (1982). His investigation of the Educational Assistance Test Program also controlled for labor market conditions, recruits, and time trends. He found that the Ultra-VEAP (ACF) program test cell increased enlistments 9.1 percent over Super VEAP, 7.7. percent over noncontributory VEAP, and 15.7 percent over the Tuition/Stipend program.

An-investigation of the impact of programs on enlistment term, attrition, and reenlistment can be done by examining the distribution of enlistment term choices during the test period (December 1980-September 1981) compared to the initial implementation of the Ultra-VEAP program nationwide as the Army College Fund (October 1981-June 1982). Such a comparison provides no formal statistical test of the differences between programs nor does it control for other factors which could affect outcomes. However, it does provide an indication of the direction and magnitude of program impacts.

Enlistment Term

Table 1 illustrates the distribution of enlistment terms during the Test Program and initiation of the ACF by test cell. The Ultra-VEAP (ACF) test cell had the greatest proportion of 2 year enlistments and the smallest percent of 4

year enlistments. Noncontributory VEAP had the smallest percent of 2 year enlistments, while the Tuition/Stipend program was most likely to enlist individuals for 4 year terms.

Enlistment terms shifted to shorter lengths with the introduction of the ACF. To assess the impact of introducing ACF one must compare the change in the ACF cell (the control) to that experienced by other cells. Table 2 provides the mean enlistment terms by test cell and time period. The average enlistment term decreased in all cells, but the decline was the least in the ACF cell. Thus, the ACF program appeared to produce a small but negative impact on enlistment term, with about a 1 percent reduction over Super VEAP and a 2 percent reduction relative to Tuition/Stipend and Noncontributory VEAP.

Attrition

Table 3 provides attrition rates by test cell during and after the Test. Rates were very similar across test cells during both periods, except for the Noncontributory VEAP test cell. The lower rates for this cell may be due to the fact that this cell has a disproportionately high representation of enlistments from the south. Other research (Weiland et al. 1986) has shown enlistments from the south to be associated with lower attrition.

Attrition declined for all test cells from FY81 to FY82. This is due in part because 4 year enlistments for FY82 still would have time to attrit. Nevertheless, the reduction in attrition rate was somewhat less for the ACF control cell than for the three other test cells. Again, the introduction of ACF reduced attrition the most in the noncontributory VEAP test cell and the least in the Super VEAP cell.

Reenlistment

Table 4 provides aggregate reenlistment rates by test cell. The percentage of reenlistments and extensions was computed relative to enlistments. Again, reenlistment rates for FY82 will be understated since many 4 year enlistments had not yet reached the end of their enlistment term. Nevertheless, the test cells would all be similarly biased downward.

The ACF test cell had a reenlistment rate 1.8 percent or more below that experienced by other test cells. During FY82 this difference disappeared for the Super VEAP and Tuition/Stipend test cells and declined relative to the noncontributory VEAP cell. In relative percentage terms, the ACF program produced over a 9 percent reduction in reenlistment rates relative Super VEAP and Tuition-Stipend programs and an 8 percent decrease over Noncontributory VEAP.

Manpower Effects

The various impacts of educational benefits can be combined to estimate the effects on first-term and career quality manpower. The first-term manpower effect is the product of the enlistment, manyear, and attrition effects. The reenlistment effect is the product of the enlistment and reenlistment effects.

Table 5 compares the FY81 test programs relative to the ACF program. The ACF program produced more first-term manpower than any of the other three programs. However, both the Super VEAP and Noncontributory VEAP produced more quality manpower reenlisting into the second term than the ACF.

DISCUSSION

No single educational benefit program was superior in terms of producing both first-term and career manpower. The ACF had the greatest positive effect

on first-term manpower, while the Noncontributory VEAP produced the most quality manpower beyond the reenlistment point. The Tuition/Stipend program was ranked last on both first-term and career manpower, while the Noncontributory VEAP was judged superior to Super VEAP.

The comparison of educational program effects on manpower via aggregate data indicates that different educational benefit programs have different effects on manpower. However, additional models should be estimated to control for variation in other factors that can affect manpower and for detailed program impacts. For example, the ACF program's lower reenlistment rate may be due solely to its increased two year enlistments. Such information can be especially useful in designing new benefit programs.

Finally, the above analysis neglects other important aspects of benefit programs. For example, the programs will also affect total attrition to the extent they reduce low quality enlistments. The impact of benefits on reserve manpower needs to be considered. Costs also should be taken into account prior to making a final determination of the most efficient benefit program. For example, the relative effectiveness of Noncontributory VEAP or ACF on career manpower will depend on their relative cost-effectiveness.

TABLE 1

ENLISTMENT TERM DISTRIBUTION BY TEST-CELL

		DEC 80-SEP 81		OCT 81-JUN 82	
TEST CELL	ENLISTMENT TERM	NUMBER	PERCENT	NUMBER	PERCENT
	2 YEARS	1464	9.5	2285	13.8
SUPER VEAP	3 YEARS	6243	40.2	6516	39.5
	4 YEARS	7814	50.3	7711	46.7
ACF (Control)	2 YEARS	945	16.5	1098	18.8
	3 YEARS	2373	41.4	2365	40.5
	4 YEARS	2413	42.1	23833	40.7
TUITION/	2 YEARS	465	10.2	783	15.6
STIPEND	3 YEARS	1683	37.0	1862	37.2
	4 YEARS	2398	52.8	2359	47.1
NONCONTRIBUTORY					
VEAP	2 YEARS	441	8.8	809	14.3
	3 YEARS	2015	40.4	2315	41.0
	4 YEARS	2532	50.8	2529	44.7

TABLE 2

AVERAGE MANYEAR DIFFERENCES

TEST CELL	DEC 80-SEP 81	OCT 81-JUN 82	PCT. CHANGE	PCT. Relative to ACF
SUPER VEAP	3.409	3.329	-2.35	-0.96
ACF (Control)	3.257	3.220	-1.14	---
TUITION/ STIPEND	3.425	3.315	-3.21	-1.84
NONCONTRIBUTORY VEAP	3.419	3.304	-3.36	-1.99

TABLE 3

ATTRITION RATE DIFFERENCES

TEST CELL	DEC 80-SEP 81	OCT 81-JUN 82	PERCENT CHANGE	PERCENT CHANGE RELATIVE TO ACF
SUPER VEAP	.365	.342	-6.30	-0.56
ACF (Control)	.354	.343	-5.77	--
TUITION/ STIPEND	.369	.343	-7.05	-1.36
NONCONTRIBUTORY VEAP	.344	.318	-7.56	-1.90

TABLE 4

REENLISTMENT RATE DIFFERENCES

TEST CELL	DEC 80-SEP 81	OCT 81-JUN 82	PERCENT CHANGE	PERCENT REL TO ACF
SUPER VEAP	19.5	12.0	-38.5	-9.29
ACF (Control)	17.7	12.0	-32.2	---
TUITION/ STIPEND	19.5	12.0	-38.5	-9.29
NONCONTRIBUTORY VEAP	21.0	13.1	-37.6	-7.96

TABLE 5

EFFECTS OF THE ACF PROGRAM

ON QUALITY MANPOWER

PROGRAM	FIRST TERM MANPOWER	CAREER
SUPER VEAP	+7.4	-1.0
TUITION STIPEND	+11.2	+6.5
NONCONTRIBUTORY VEAP	+ 4.3	-2.3

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Working Paper MPPRG 87-29

PROJECT B:

IMPROVING PERSONNEL PERFORMANCE THROUGH ASSIGNMENT POLICY

Edward J. Schmitz

June 1987

REVIEWED BY: [signature]

APPROVED BY: [signature]

U.S. Army Research Institute for the Behavioral and Social Sciences
5001 Eisenhower Avenue, Alexandria VA 22333

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PROJECT B:

IMPROVING PERSONNEL PERFORMANCE THROUGH ASSIGNMENT POLICY

Edward J. Schmitz

June 1987

The U S Army Research Institute (ARI) has developed the Enlisted Personnel Allocation System (EPAS) to recommend training assignments to new recruits. This system, based upon a combination of optimization and decision rules, can increase soldier performance substantially over the present assignment system. Results of EPAS simulations are compared with the present system and with increased enlistment standards to determine the costs and benefits of improving performance in different ways. Finally, economic and psychological models are used to assess the value of these performance increases to the Army.

THE ARMY'S PRESENT ALLOCATION SYSTEM

The Army relies upon a computer program that recommends jobs, or military occupational specialties (MOS), to new recruits. The present system includes data on a number of different factors, including applicant and MOS characteristics.

The assignment is determined by three kinds of information. The first are the occupation-specific job standards. Aptitude area qualifying scores are used to determine whether an applicant is qualified for a particular MOS. Scores above the minimum have no impact on assignment. Second, distributional goals in terms of the AFQT are set for each job. These quality goals assure that the population of recruits entering each MOS has at least a certain number of above average performers, and no more than a specific percent of those in the lowest eligible test category (IV). The final factor in the assignment process is the job's characteristics. This includes the priority of the job, the time available to fill training seats, and the proportion of the annual training program remaining.

The resulting system is successful in meeting several important goals. The present system does an acceptable job of filling requirements. For example, in FY84 the system met total accession requirements, 90 percent of the individual MOS training requirements, and 88 percent of the MOS quality goals.

However, the present system does little to improve job performance. Considerable research has shown the relationship of composite scores to a number of different job performance criteria (Armor 1982, Fernandez 1985, McLaughlin et al 1984). An efficient placement system would tend to place candidates into the jobs where they have the greatest likelihood of success. The assignment possibilities range from no use of classification data (random assignment) to placement of recruits in the job that maximizes total performance, given job demands (optimal assignment). On such a scale, random assignment would produce a mean aptitude area score of 106.7, while optimal assignment would place recruits in MOS where their aptitude score was 113.9. The present system, which assigns recruits to jobs with an average aptitude area score of 108.1, is capturing less than one fifth of the potential assignment efficiency.

The reason for the relatively low assignment efficiency is the reliance on low job standards for a high quality recruit population. The average recruit today qualifies for 85 percent of the jobs in the Army. The average test category I-IIIA recruit qualifies for 96 percent of all jobs.

THE DESIGN OF THE ENLISTED PERSONNEL ALLOCATION SYSTEM

While optimizations such as those done by Schmitz and Nelson (1984) and Fernandez (1985) have indicated that job performance can be increased considerably, these batch assignments would be infeasible under present assignment procedures. Applicants must be placed in jobs at the time they negotiate their enlistment contract. This situation reflects a class of operations research problems referred to as the secretary problem.

Project B, the Enlisted Personnel Allocation System, was developed by ARI to improve the assignment of new recruits to their training MOS. EPAS uses a three step strategy to assign recruits to MOS. First, a plan is developed for the allocation of the recruits expected by the Army over the next year. This plan is then used to guide the training seat recommendations of each prospective soldier who is offered an enlistment contract. Finally, the system is frequently updated to assure that the overall plan is in close agreement with current supply and demand.

Figure 1 shows the design of EPAS. Projections are made of both requirements and enlistment contracts by month over a one year planning horizon. Requirements are aggregated into about fifty groups of MOS that are similar in terms of gender restrictions, quality goals, and aptitude area composite. Aggregate supply forecasts can come from a supply model such as Horne (1985) or US Army Recruiting Command missions. These forecasts can be disaggregated by education, gender, AFQT, and predicted performance. Two measures of performance have been used thus far: technical job performance as predicted by the aptitude area score, and attrition as predicted by characteristics of the recruit and job (Manganaris and Schmitz 1985, Manganaris and Phillips 1985).

The allocation problem is solved by a network optimization procedure that assures all MOS requirements and quality goals are met and performance is maximized. Each of the supply groups has identified those categories of training seats where the Army can be expected to receive the greatest payoff from their performance.

However, it is not sufficient to evaluate the payoff for the best possible assignment; the Army needs to know what the relative values of other possible assignments are. Thus, the solution to the planning problem generates an ordered list of MOS assignments. Associated with each alternative assignment is a payoff that reflects how close the alternative is to the optimal assignment. This weight is combined with detailed information on applicant and job characteristics so that each recruit can be evaluated against the actual training seats available to him or her. This part of the decision algorithm is analogous to the present Army system and to procedures used by the Air Force and Navy. The guidance provided by the planning system assures that the many goals and constraints on the distributional aspects of the assignment are met along with improving performance. The frequent updates of the forecasts and planning guidance assure that the recommendations remain on track with policy objectives.

SIMULATION RESULTS

Many simulations have been made using EPAS to test the system and identify what kinds of performance gains are possible. Simulations have been performed to assess whether the proposed design performs better than alternatives, examine the sensitivity of the results to changes in different factors, and identify whether the system generates sufficient benefits to be worth the cost of implementation. These analyses have indicated that very substantial improvements in assignments are possible and these improvements should be very valuable to the Army.

The results of the assignment simulations using EPAS show that the average aptitude area score would increase from 108.1 to 112.1. This represents a gain of nearly three times the difference between the current system and a policy of random assignment of the recruit population.

An alternative approach for raising job performance is to increase job standards. Such a policy will eliminate many of the less productive job matches and increase the probability a recruit will enter a job that he or she is good at. However, such a policy will increase recruiting costs, since some of the people presently enlisting will be disqualified, and alternative candidates will need to be found.

Scenarios of raising all MOS qualifying scores 5 and 10 points while keeping the present job placement policy were performed. Raising the entrance standards by 10 points increased the average performance of qualified applicants by 2.7 points, but eliminated 5.2 percent of the previously acceptable recruits.

Larger predicted performance gains were produced from efficient assignment with EPAS than by raising standards. Furthermore, EPAS accomplished these gains without increasing recruiting costs. However, the EPAS gains would be affected more by applicant choice than a standards increase. The US Army Recruiting Command is presently experimenting with guidance counselor incentives to increase the probability of selling the Army's recommendation to the recruit.

ESTIMATING THE VALUE OF IMPROVED ASSIGNMENTS

Policy makers are concerned about the value of alternative assignment strategies. A model of value can be used to determine whether proposed improvements are worth development costs, or identify areas where additional resources or procedures are warranted.

Five ways have been identified to evaluate the value to the Army of improving the assignment system. These include:

- o System efficiency model
- o Performance indicators
- o Organizational output models
- o Psychological utility
- o Economic opportunity costs

The current assignment system has considerable resources devoted towards improving soldier performance through job assignment. Roughly two thirds of the ASVAB, or 2.5 hours for each prospective applicant, provides only classification information in the form of subtests used to construct aptitude area composites. Additional resources are devoted to setting qualifying scores by TRADOC and the ODCSPER. Other costs are generated by the current computer system.

The Enlisted Personnel Allocation System triples the performance gains captured from the available job performance system. Given the relatively small costs involved in implementation compared to the costs of maintaining and operating the present classification and assignment system, this is likely to be highly cost-effective.

A large body of literature has been developing as to how soldiers with particular test scores perform on important job tasks. Project A, the Army's project to improve the selection and classification of personnel, has collected a substantial data base of highly reliable performance data. This data base will permit the translation of test score improvements into quantitative performance indicators that can be used to describe how the capabilities of soldiers will change as their characteristics change.

It may be possible to generalize from such performance indicators to assess the impact of soldier performance against estimates of organizational output. Ideally, one would like to include factors to reflect soldier attributes in the kinds of combat simulation models used to assess unit performance. While several approaches have been made in this direction (Miller and Bonder 1982, Scribner et al. 1986), much work would need to be performed before such simulation models could be estimated.

Psychological utility models based upon the work of Brogden (1959) have attempted to measure the benefits of improved classification. Boudreau and

Berger (1985) have examined the application of such utility analysis to organizational productivity and recommended an approach that we will adapt here to provide one estimate of the value of potential gains. By estimating the salary paid to workers, and using the 40 percent rule of thumb developed in previous research on the relationship of the standard deviation of performance to salary (Hunter and Schmidt 1982), the dollar value of predicted performance gains can be calculated.

It is possible to use the Boudreau and Berger approach to estimate the productivity gains from improved assignment. If one assumes that the assignment decision is relevant to first term performance, one can estimate the dollar value of performance gains. Using regular military compensation for salary, 2.09 years as the average enlistment term served by a recruit (3.27 years - 36 percent attrition), and the 40 percent of salary rule, the standard deviation of performance is $17,811.

Using this procedure, the dollar value of the gains from ARI's improvements to the assignment system become $277.9 million for implementing EPAS.

A fifth approach to evaluating the benefits of improved MOS assignment focuses on the "opportunity costs" of retaining the current system. The new assignment procedure will raise performance by four aptitude area points. This performance increase could also be achieved under the present system by simply recruiting more high quality soldiers and fewer individuals in test categories IIIB and IV. The cost of recruiting these additional I-IIIAs can be used as a measure of the value of the performance gains resulting from improved assignment.

The impact of introducing EPAS would require large increases in accession quality. In order to raise the average aptitude area score of assigned soldiers by 4 points one would need to recruit 85.9 percent category I-IIIAs and no category IVs. This would be an increase of 23.5 percent additional category I-IIIAs.

Projected out to an accession population of 130,000, these quality mix changes become very dramatic. The gains from introducing EPAS would require 30,500 additional I-IIIAs. There are no reliable figures as to what these quality increases would cost to achieve with additional recruiting resources. Using the Polich et al. (1986) estimate that it would cost about $16,000 in bonuses for each additional high quality recruit, the performance gains resulting from EPAS would be valued at 489 million dollars annually.

SUMMARY

The present Army job assignment system has little impact on soldier performance. This is because the present system relies on qualifying scores to perform allocation, and the present recruit population's capabilities are substantially above the minimum required for most jobs.

Job performance can be improved by either raising standards or assigning applicants more efficiently. In the selected scenarios that have been evaluated it appears that improving the efficiency of assignments is more cost effective

than raising standards. Improving the assignment system will also enhance the Army's ability to make use of improved performance predictors.

Several alternatives are available for evaluating the benefits of improved performance. Where quantitative estimates are available, it appears that productivity can be improved a modest, but significant amount. Given the number of assignment decisions the Army makes each year, the benefits would be expected to be quite substantial.

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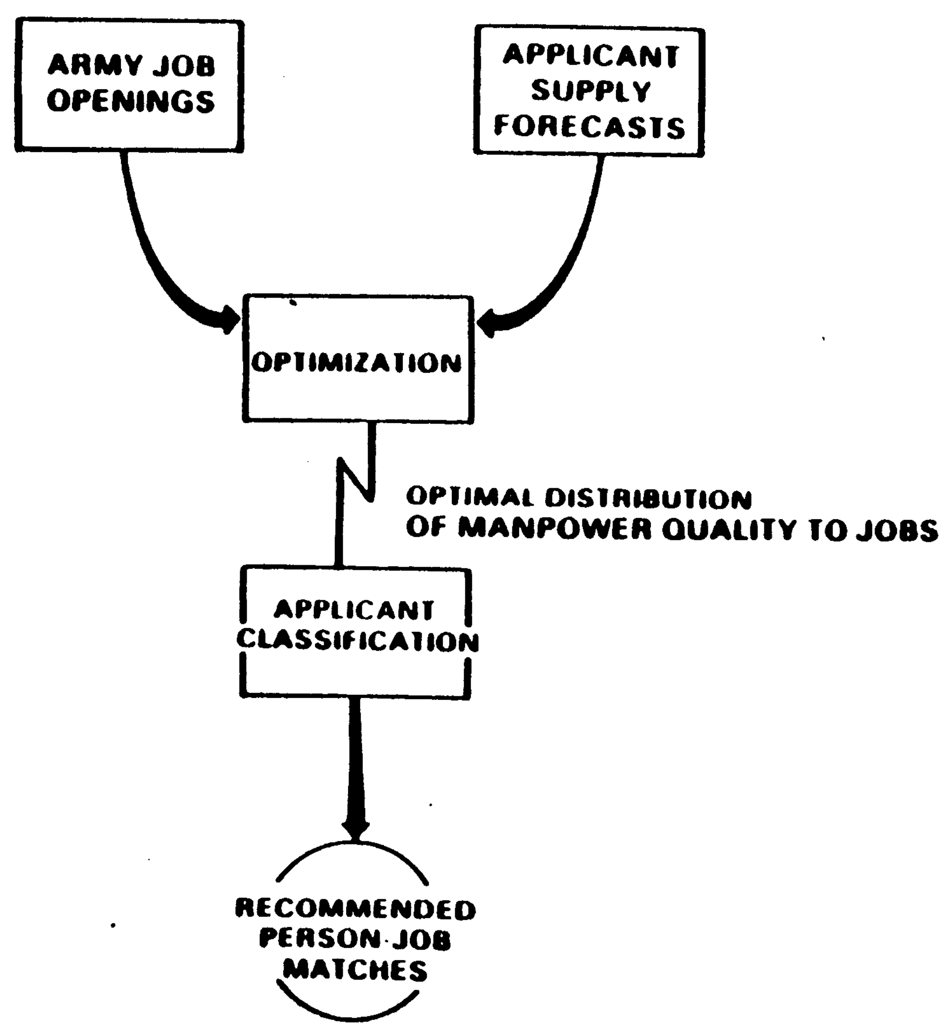
EPAS
APPLICANT CLASSIFICATION



EPAS
Project B

Manpower and Personnel Policy Research Group

Working Paper MPPRG 88-4

IMPROVING THE ARMY'S CLASSIFICATION POLICY:

THE DESIGN OF THE ENLISTED PERSONNEL ALLOCATION SYSTEM

EDWARD SCHMITZ
February 1988

Reviewed by: Roy D. Nord

Approved by: Curtis L. Gilroy

Curtis L. Gilroy
Chief, Manpower and Personnel
Policy Research Group

Cleared by:
for NEWELL K. EATON, Director

Manpower and Personnel Research Laboratory

U. S. Army Research Institute
for the Behavioral and Social Sciences
5001 Eisenhower Avenue, Alexandria, VA 22333-5600

I. INTRODUCTION

The U S Army Research Institute (ARI) has developed the Enlisted Personnel Allocation System (EPAS) to recommend training seats to new recruits. This system, based upon a combination of optimization and decision rules, can increase soldier performance substantially over the present assignment system. The design of EPAS and how it will change applicant classification are the topic of this paper.

II. THE ARMY'S PRESENT ALLOCATION SYSTEM

The Army relies upon a computer program that recommends jobs, or military occupational specialties (MOS), to new recruits. The present system includes data on a number of different factors, including applicant and MOS characteristics.

The assignment is determined by three kinds of information. The first is the occupation-specific job standards. Aptitude area qualifying scores are used to determine whether an applicant is qualified for a particular MOS. Scores above the minimum have no impact on assignment. Second, distributional goals in terms of the AFQT are set for each job. These quality goals assure that the population of recruits entering each MOS has at least a certain number scoring above average, and no more than a specific percent of those in the lowest eligible test category (IV). The final factor in the assignment process is the job's characteristics. This includes the priority of the job, the time available to fill training

seats, and the proportion of the annual training program remaining.

The resulting system is successful in meeting several important goals. The present system does an acceptable job of filling requirements. For example, in FY84 the system met total accession requirements, 90 percent of the individual MOS training requirements, and 88 percent of the MOS quality goals.

However, the present system does little to improve job performance. Considerable research has shown the relationship of composite scores to a number of different job performance criteria (Armor 1982, Fernandez and Garfinkle 1985, McLaughlin et al 1984). An efficient placement system would tend to place candidates into the jobs where they have the greatest likelihood of success. For example, the assignment problem presents possibilities that range from no use of classification data (random assignment) to placement of recruits in the job that maximizes total performance, given job demands (optimal assignment). On such a scale, random assignment of 1984 accessions would produce a mean aptitude area score of 106.7, while optimal assignment would yield an average aptitude score of 114.4 the same group of recruits (Figure 1). The present system, which produced an average aptitude area score of 108.5, is capturing less than one fourth of the potential assignment efficiency.

The reason for the relatively low assignment efficiency is the reliance on low job standards for a high quality recruit population, combined with the focus on filling requirements. The average recruit today

qualifies for 85 percent of the jobs in the Army (Figure 2). The average test category I-IIIA recruit qualifies for 96 percent of all jobs. Furthermore, no attrition information is used in making assignments, although research has shown that the effects of many recruit characteristics (gender, education, and test score) on turnover rates vary significantly across occupations (Manganaris and Schmitz 1985).

Requirements have been the overriding concern in Army recruit allocation. When the current allocation system was developed, finding any place for minimally qualified recruits was the overriding objective. More recently, the emphasis has been on obtaining a distribution of test categories within jobs. Thus, to assure that requirements are met, the allocation system has evolved so that virtually all of the weight is on meeting requirements; the only concern is whether the applicant meets the minimum job standard. Since standards are low, this approach yields low classification efficiency.

III. THE DESIGN OF THE ENLISTED PERSONNEL ALLOCATION SYSTEM

While optimizations such as those done by Schmitz and Nelson (1984) and Fernandez and Garfinkle (1985) have indicated that job performance can be increased considerably, these batch assignments would be infeasible under present assignment procedures. Applicants must be placed in jobs at the time they negotiate their enlistment contract. This situation in analogous to a class of operations research problems referred to as the

secretary problem (Tamaki 1984).

Project B, the Enlisted Personnel Allocation System, was developed by ARI to improve the assignment of new recruits to their training MOS. EPAS uses a four step strategy to assign recruits to MOS (Figure 3). First, forecasts are made of the numbers and types of applicants available for assignment over the next 12 months. Then a plan is developed for the allocation of these recruits over the next year. This plan is used to guide the training seat recommendations made to each prospective soldier who is offered an enlistment contract. Finally, the system is frequently updated to assure that the overall plan is in close agreement with current supply and demand.

Figure 4 shows the EPAS forecasting approach. Projections of job vacancies are made elsewhere by the Army. These provide the monthly training seats that must be filled over the next year. Aggregate supply forecasts can come from a supply model such as Horne (1985) or US Army Recruiting Command missions. These forecasts are disaggregated by education, gender, AFQT, and predicted performance into about 80 separate groups. For example, high school graduate males with above average AFQT scores are disaggregated into about 35 separate groups according to job specific test scores.

Figure 5 presents an example of two supply groups. Both groups are identical with respect to recruiting characteristics (graduate males, test category I-IIIA) and would receive identical recommendations under the

current allocation system. EPAS would be likely to recommend assignments for the first group in CL, EL, GM, and ST aptitude clusters, while the second group would likely be assigned to jobs in the CO, MM, OF, or SC aptitude areas.

Once information is available about the demand for jobs and supply of recruits, a satisfactory plan must be developed. This plan is complicated by the fact that it must be concerned with not simply filling jobs or achieving performance goals, but must attempt to achieve both goals while satisfying a large number of distribution and timing constraints. For example, neither too many or too few recruits may be brought into the Army each month, and the distribution of AFQT scores in each occupation over the course of the year must achieve the goals for each occupation. The time dimension is a critical complicating factor that must be included in the problem. Very few recruits enter the Army in the same month they enlist; nearly all enlistments enter the Delayed Entry Program for up to twelve months.

Figure 6 illustrates how EPAS assigns each of the 80 supply groups to jobs over the next twelve months so as to maximize expected performance, taking into account all of the various policies and constraints. These objectives and constraints are translated into a system of equations which is then solved using mathematical programming techniques to identify the combination of supply group-job-month assignments that satisfy policies and produce the highest performance level. Two measures of performance have been used thus far: technical job performance as predicted by the aptitude

area score, and attrition as predicted by characteristics of the recruit and job (Manganaris and Schmitz 1985, Manganaris and Phillips 1985).

Figure 7 shows how the results of the planning model are then used to guide the job recommendations for each applicant. The planning problem generates a list of preferred MOS assignments for each supply group. Alternative assignments are evaluated by how close the alternative is to the optimal assignment. This information is combined with detailed data on applicant and job characteristics so that each recruit can be evaluated against the actual training seats available to him or her. This part of the decision algorithm is analogous to both the present Army system and procedures used by the Air Force and Navy. The guidance provided by the planning system assures that the many goals and constraints on the distributional aspects of the assignment are met while improving performance.

The frequent updates of the forecasts and planning guidance assure that the recommendations remain on track with policy objectives. Since the DEP holds over three months of recruits, there is time to correct errors in forecasts. Major changes in recruit supply or training plans could require separate analysis. In fact, one additional benefit of EPAS is the capability to quickly perform simulation analyses of the impact of changes in the recruiting environment. It is possible to investigate how changes in enlistment standards, recruit supply, or training schedules will impact on the performance and costs of the Army's enlisted force.

IV. SUMMARY

The assignment of soldiers to job training presents a difficult problem, Nearly 3,000 recruits be assigned to over 250 different jobs each week at over 60 locations. Under the current system each recruit is assigned solely according to the priorities of the seats open at the time of contract. While this system performs well at filling requirements, there is virtually no capacity to place recruits into the jobs they can be expected to do best.

EPAS provides a strategy for both satisfying requirements and improving job performance. By forecasting and planning prior to the arrival of recruits it is possible to improve placement substantially. Decisions can be made to place recruits in a way that more closely approximates optimal assignment policy.

Furthermore, this approach provides a number of ancillary advantages. The impact of assignment decisions on important management indicators can be calculated. The Army can assess how assignment strategies will affect job performance, attrition, MOS fill, and the composition of the DEP. Also, EPAS can be used to simulate alternative policies and environments. The impact of changing requirements, recruit supply, or enlistment standards can be evaluated prior to their occurrence.

EPAS is not yet operational and definitive research has not been performed on some of these questions. However, many such simulations have

been performed comparing the outcome of assignments with EPAS to the current system (Schmitz and McWhite 1986). These analyses have shown EPAS can reduce attrition and improve job performance substantially, even when applicant choice is accounted for. Furthermore, simulations have shown that EPAS can also adapt to meet requirements under volatile recruiting environments. With better planning capability there will be less reactive crisis management and fewer disruptions of recruiting and training.

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FIGURE 1. The Range of Assignment Possibilities

EPAS CAN IMPROVE SOLDIER PERFORMANCE

- MEETS REQUIREMENTS
- REDUCES ATTRITION
- RAISES AVERAGE APTITUDE AREA SCORES

MORE MANYEARS AND BETTER PERFORMANCE

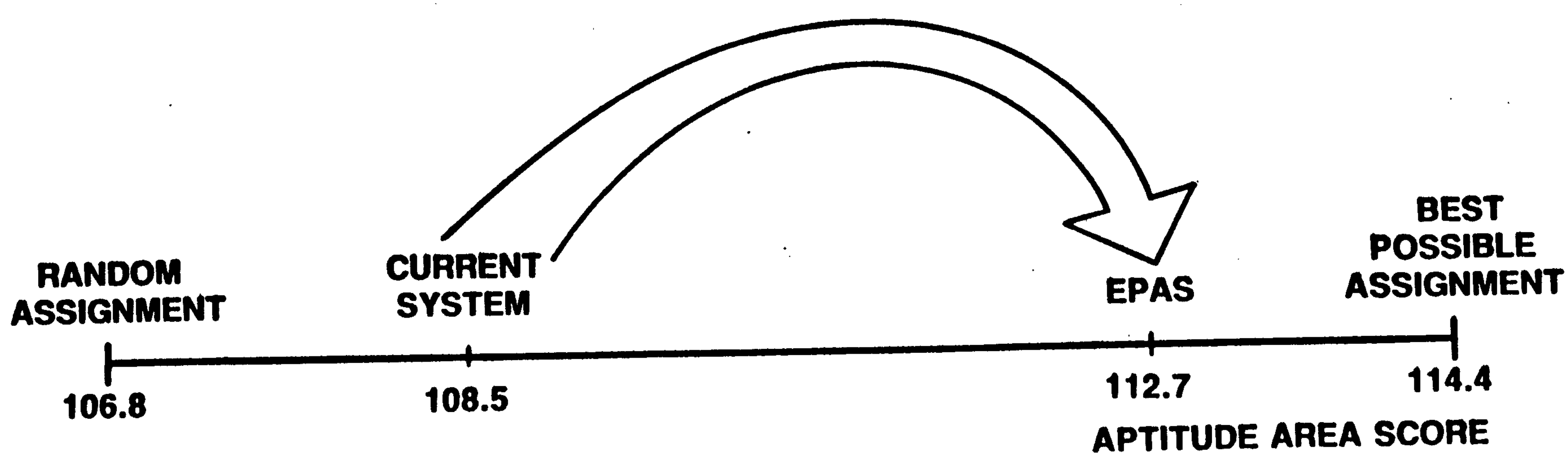


FIGURE 2. Current Recruit Job Qualifications

CURRENT SYSTEM DOES NOT DISCRIMINATE AMONG APPLICANTS WITH AT LEAST MINIMUM QUALIFICATIONS

- **AVERAGE RECRUIT QUALIFIES FOR 85% OF JOBS**
- **AVERAGE I-IIIA RECRUIT QUALIFIES FOR 96% OF JOBS**

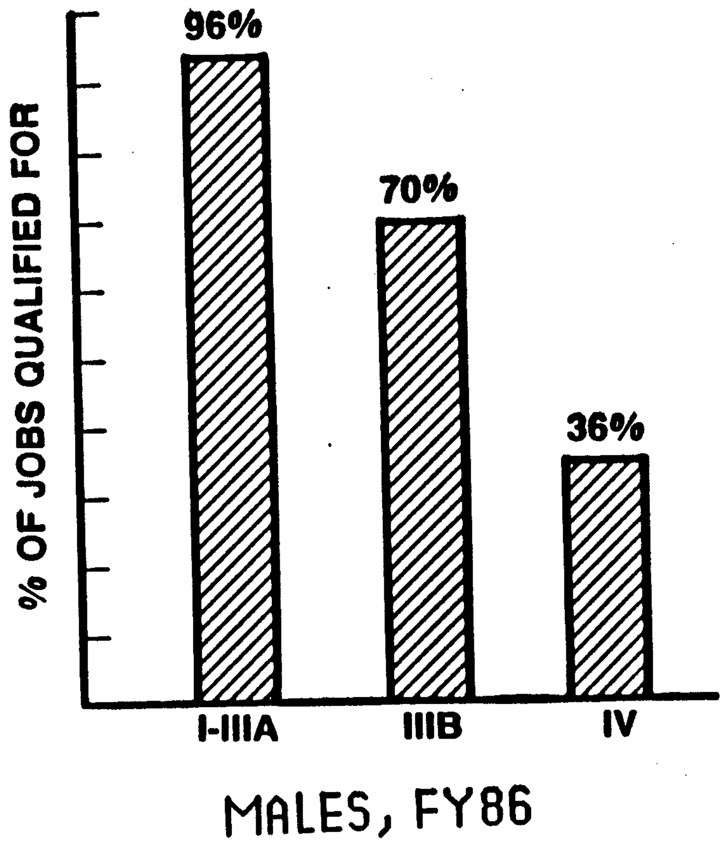


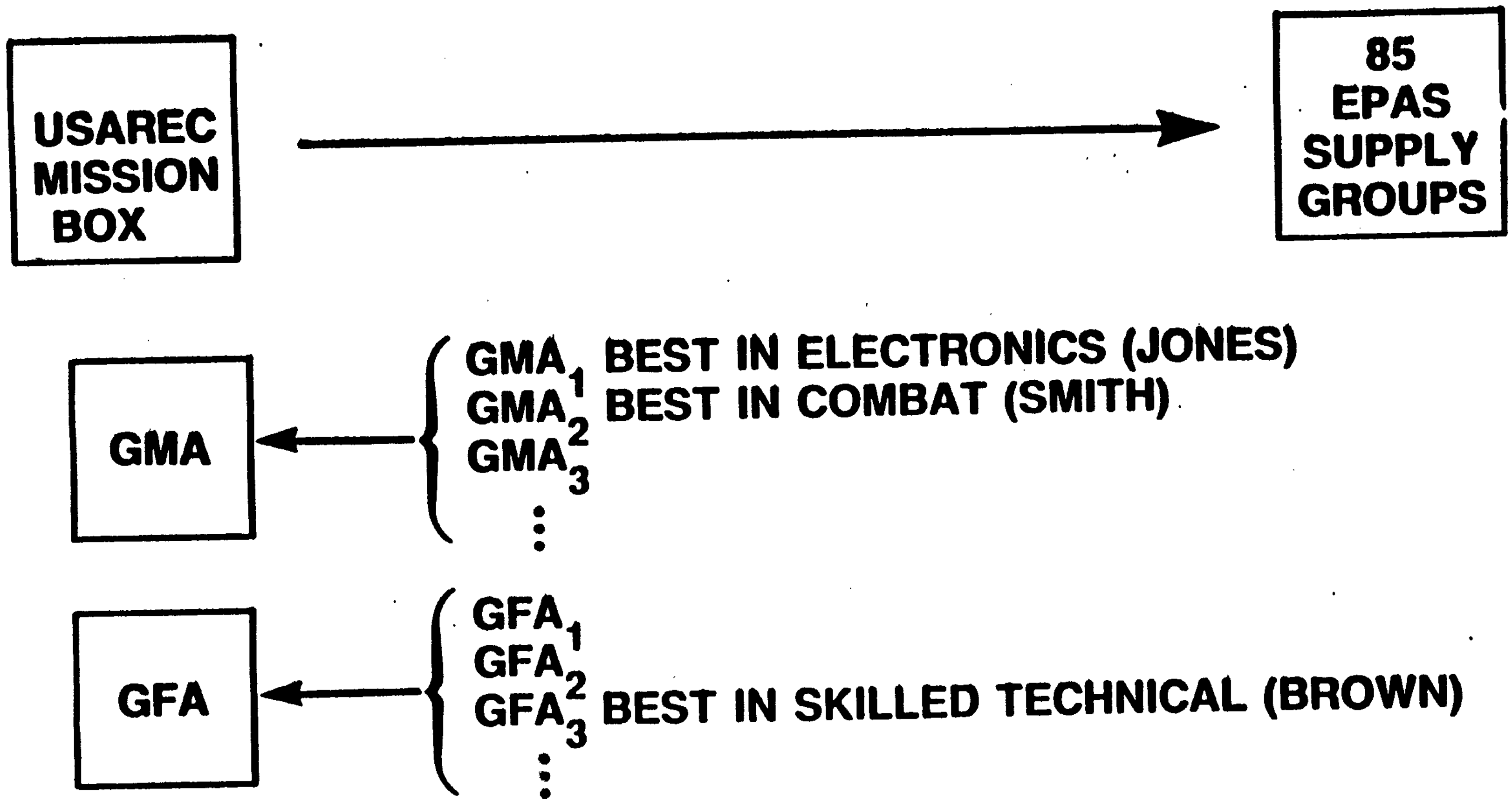
FIGURE 3. EPAS Assignment Strategy

EPAS: HOW DOES IT WORK?

- FORECASTS SUPPLY OF RECRUITS
- DEVELOPS A PLAN TO MEET REQUIREMENTS
- USES PLAN TO GUIDE MOS RECOMMENDATIONS
- UPDATES PLAN FREQUENTLY TO KEEP SYSTEM ON TRACK

FIGURE 4. EPAS Forecasting Approach

FORECASTING SUPPLY



SUPPLY GROUPS COMBINE TO FORM MISSION BOXES

SUPPLY GROUPS SUPPORT MORE ACCURATE JOB PLACEMENT

FIGURE 5. EPAS Supply Groups

EXAMPLES OF EPAS SUPPLY GROUPS

SAME MISSION BOX, DIFFERENT PERFORMANCE POTENTIAL

MALE

GRADUATE

TSC I - IIIA (II)

	CL	CO	EL	FA	GM	MM	OF	SC	ST
GMA_1 (JONES)	$\boxed{124}$	114	$\boxed{127}$	119	$\boxed{124}$	115	114	118	$\boxed{124}$
GMA_2 (SMITH)	111	$\boxed{126}$	111	117	113	$\boxed{123}$	$\boxed{123}$	$\boxed{123}$	112

29 SUPPLY GROUPS RANGING FROM 700 TO 3,500 RECRUITS

FIGURE 6. EPAS Allocation Planning

EPAS DEVELOPS ACCESSION PLANS

- **IDENTIFIES A PLAN THAT MEETS:**
  - ANNPRO
  - QUALITY GOALS
  - DEP POLICY
- **PLAN TAKES INTO ACCOUNT**
  - SUPPLY FORECASTS
  - TRANINING SCHEDULE
  - MOS PROPENSITY
  - GENDER RESTRICTIONS
  - PERFORMANCE

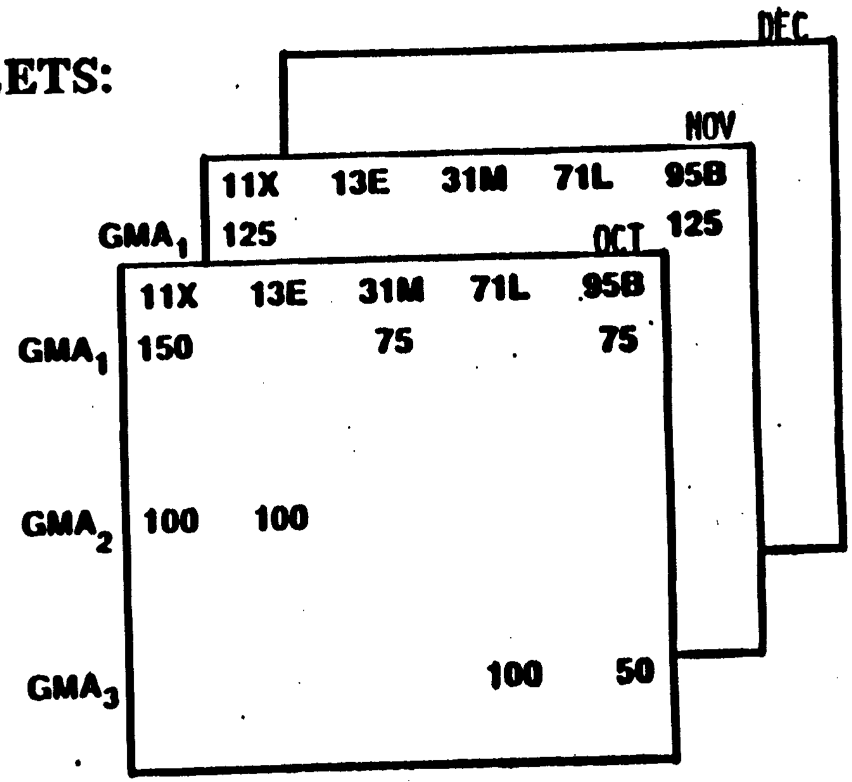
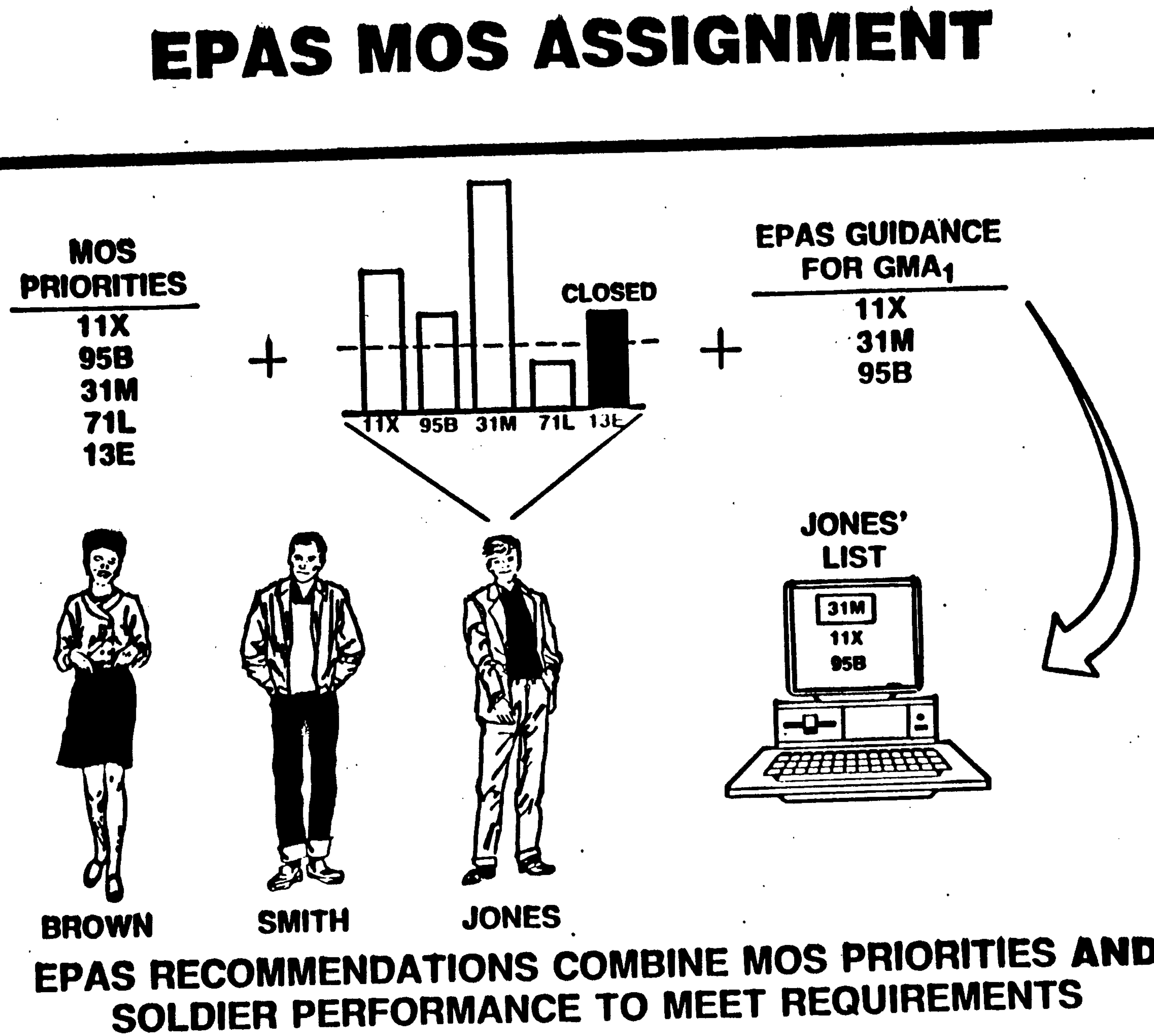


FIGURE 7. EPAS Applicant MOS Assignments



Manpower and Personnel Policy Research Group

Working Paper MPPRG 88-6

POLICY ANALYSIS AND STRATEGIC PLANNING
IN CLASSIFICATION AND ASSIGNMENT

EDWARD SCHMITZ

February 1988

Reviewed by: Roy D. Nord

Approved by: Curtis L. Gilroy

Curtis L. Gilroy
Chief, Manpower and Personnel
Policy Research Group

Cleared by:

NEWELL K. EATON, Director

Manpower and Personnel Research Laboratory

U. S. Army Research Institute
for the Behavioral and Social Sciences
5001 Eisenhower Avenue, Alexandria, VA 22333-5600

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I. INTRODUCTION

The development of the Enlisted Personnel Allocation System (EPAS) has resulted in improvements in the development and analysis of policies with respect to the management of the Army's placement of recruits into military occupational specialties (MOS). This paper discusses several of the kinds of policy analyses that have been performed through EPAS.

II. EPAS AND MANPOWER PLANNING

The operational version of EPAS will deal with short-term classification problems- which specific MOS to recommend to each prospective recruit. Many policies and procedures will be fixed under these conditions. The requirements will be known, enlistment standards will be set, and recruiting resources will be in place.

EPAS can be used to perform simulations of the classification and assignment environment. Figure 1 illustrates some of the policy analysis simulations that could be performed using EPAS. Changes in the training seat schedule or Delayed Entry Program (DEP) policy can be evaluated to determine first of all if they are feasible, and secondly, what impact they

would have upon major indicators, such as recruiting costs, attrition, or job performance.

Often there is an interest in broader policy analysis issues than those of detailed monthly or weekly accession management. Several variants of EPAS have been developed by ARI scientists for examining such issues as:

o DEP policy

o Design of classification tests

o Mobilization

For example, DEP policy is an input to the operational EPAS. However, there has been interest from the U.S. Army Recruiting Command (USAREC) in determining what kind of DEP policy would be most reasonable. Manganaris and Phillips (1985) performed research upon some of the more significant features of the DEP. They found that time in the DEP resulted in both costs and benefits to the Army.

Figure 2 illustrates the tradeoff that results from time in the DEP. As a recruit spends more time in the DEP his probability of failing to enlist increases. This is portrayed by the DEP loss curve. However, other research has found that time in the DEP is inversely related to in-service attrition. This is shown by the attrition loss probability curve.

The optimal DEP policy depends upon a number of factors: the

steepness of the two loss curves and the relative costs of each kind of loss. Also, while the capability existed to identify global optimal solutions, many other management factors would need to be included before broad changes are made. Nevertheless, a sensitivity analysis found that USAREC should move towards a larger DEP inventory. Based upon this research, the Commanding General of USAREC increased DEP inventory, resulting in a reduction of in-service attrition that saved the Army many millions of dollars.

Another area where EPAS has provided useful policy analyses is in the development of classification tests. Alternative aptitude composites were developed by the Army Research Institute. Through simulations (Schmitz and Nord 1987) it was possible to:

- o Identify the composites with the greatest potential for improving job performance

- o evaluate the impact of the new composites upon job performance under the existing classification and assignment system

- o estimate the gains in productivity that would result from implementing new classification measures with EPAS.

The simulations performed could not only identify the set of tests that would improve job performance the most, they also could estimate the benefits of alternative policies. The effectiveness measure used in this analysis is the number of above average recruits required to achieve a

particular performance level (Nord and Schmitz 1988). More accurate tests and classification systems can achieve performance levels that would require many additional high performers if the present system is used to make assignments.

Figure 3 illustrates the kinds of improvements that would occur under different implementation scenarios. The alternatives evaluated include:

- o Two sets of classification composites
  - Current aptitude area scores
  - Composites including new mechanical maintenance (MM)
- o Two allocation mechanisms
  - Current system
  - EPAS

Modifying the classification tests by improving the MM classification test would produce little improved performance under the current classification system. However, when EPAS is implemented the new classification test's value increases dramatically. The change in classification efficiency will produce a performance increase equivalent to 6,000 below average recruits with high quality recruits.

Other research remains to be performed in the classification area that will be of great significance to the Army. For example, EPAS could be tied in directly to the management of enlistment incentives. Data from EPAS on the rate at which MOS are filling could serve as the basis for efficient bonus and Army College Fund use. Once analyses have been performed to assess the sensitivity of MOS fill to monetary and nonmonetary

incentives it will be possible to integrate these incentives into the assignment algorithm of EPAS.

Finally, research in the assignment and classification area needs to be concerned with long term research issues. In the long term not only do the characteristics of the people vary, but the assignments themselves can be changed. The numbers and skills required become a decision variable in the assignment problem.

The MANPRINT model is the Army's approach to integrating manpower planning into the system design process. There is certainly a place for classification and assignment modeling in the MANPRINT arena. Developers need feedback on the specific characteristics and skills that will be available within the Army manpower pool. Models could be designed which could aid this process by evaluating the manpower costs of alternative force structures. Such an effort would be a natural connection between the assignment models and the system developers.

III. REFERENCES

Manganaris, A., and C. Phillips (1985). The Delayed Entry Program: A Policy Analysis. Alexandria, VA: US Army Research Institute (TR 679).

Nord, R., and E. Schmitz (1987). Evaluating Improvements to Classification and Assignment Policy. Alexandria, VA: US Army Research Institute.

Schmitz, E. and R. Nord (1988). Estimating the Benefits and Costs of Classification and Assignment Systems. Alexandria, VA: US Army Research Institute (MPPRG Working Paper 5).

FIGURE 1. EPAS Policy Analysis Capabilities

EPAS CAN BE USED FOR POLICY ANALYSES

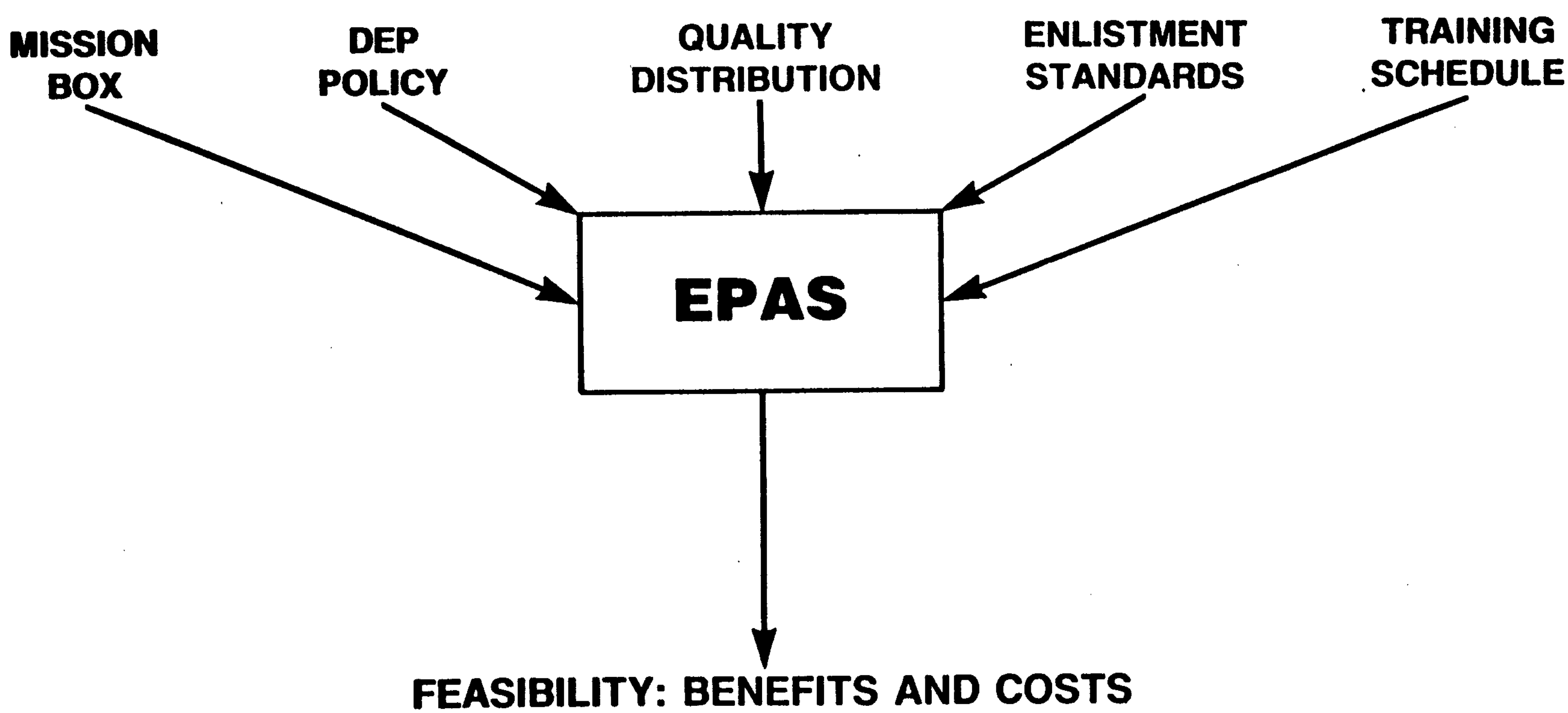


FIGURE 2. DEP Loss Tradeoff Curves

TOTAL LOSS COMPOSITION

Male I-IIIA H.S. Graduate, MOS 31M

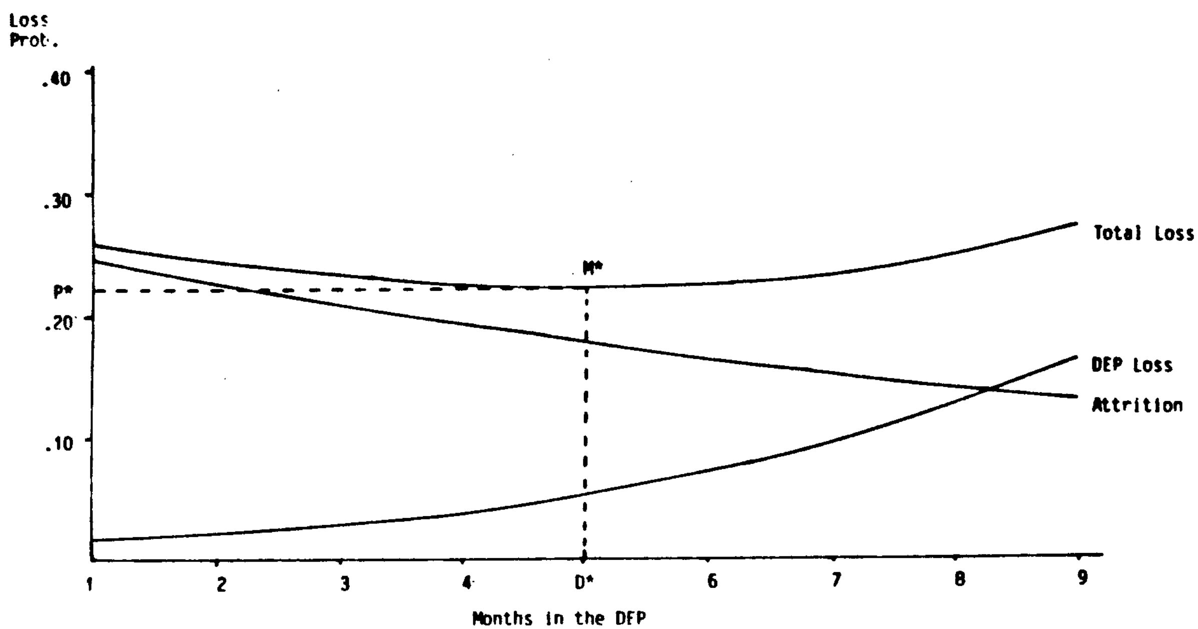
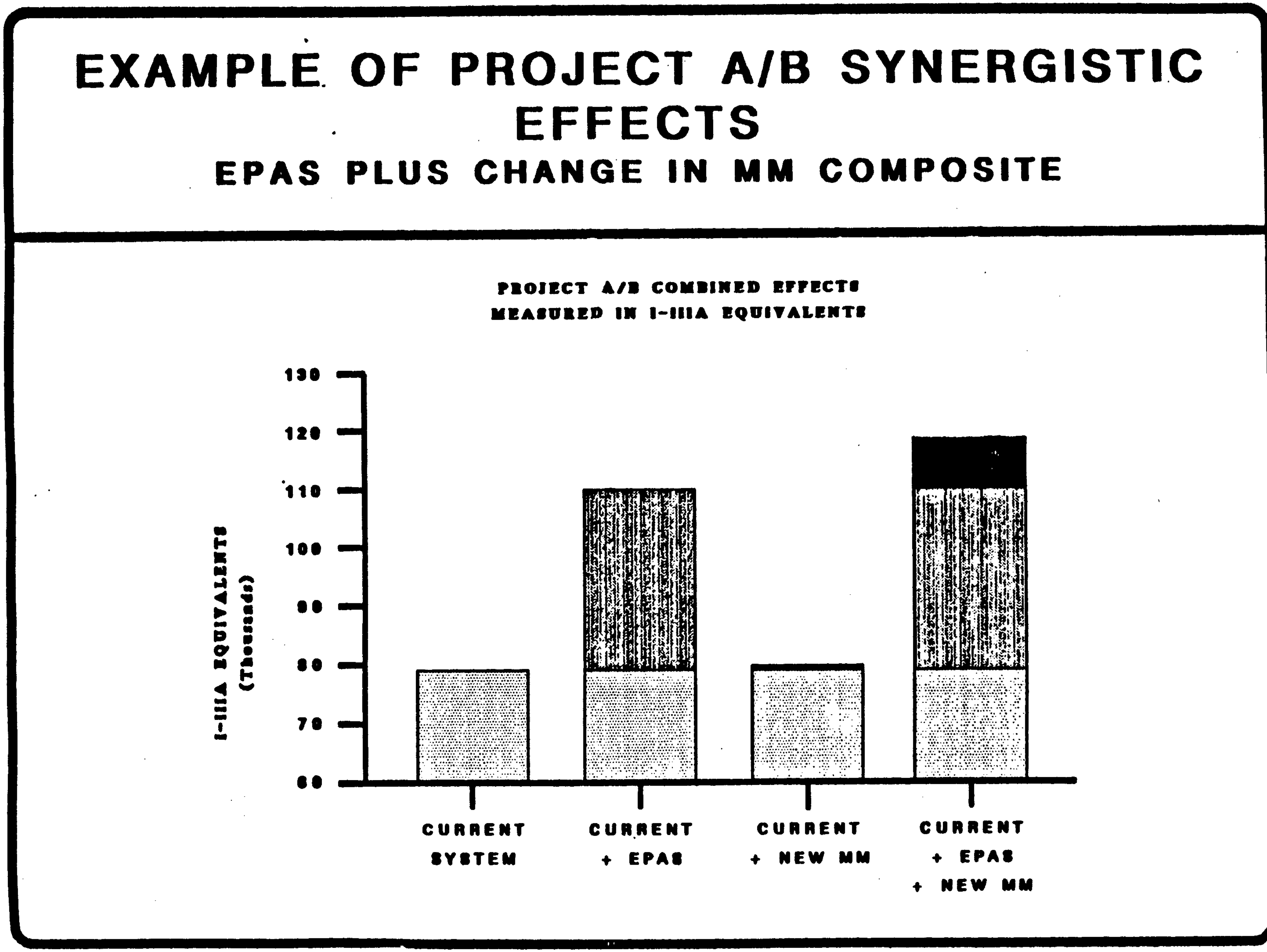


FIGURE 3. Performance Gains from EPAS and Classification Changes



Manpower and Personnel Policy Research Group

Working Paper MPPRG 90-04

DEVELOPMENT OF A BEHAVIORALLY-BASED COST MODEL FOR EVALUATING MILITARY EDUCATIONAL BENEFITS

EDWARD J. SCHMITZ

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Approved by:

Curtis L. Gilroy
Chief, Manpower and Personnel
Policy Research Group

MANPOWER AND PERSONNEL RESEARCH LABORATORY

**U.S. ARMY RESEARCH INSTITUTE
FOR THE BEHAVIORAL AND SOCIAL SCIENCES**
5001 Eisenhower Avenue, Alexandria, VA 22333-5600

DEVELOPMENT OF A BEHAVIORALLY-BASED COST MODEL FOR EVALUATING MILITARY EDUCATIONAL BENEFITS

Edward J. Schmitz

Educational benefits, particularly the Army College Fund (ACF), have been an important enlistment incentive for the Army since 1979. Over 250,000 highly capable young men and women have enlisted in the Army College Fund AND its predecessor program since that year.

Educational benefits are a unique incentive. Unlike the bonus, or even skill training, the individual only receives the benefits of the program _after_ completion of military service. Thus, an individual who enlists for four years and attends college for four years would not have completed his or her benefit usage until at least eight years after enlisting.

The delay between the awarding of the benefit and its actual use makes it difficult to assess the cost of this program. Also, the nature of the current Army College Fund makes it difficult to use the experience of earlier veteran educational benefit programs. Unlike the GI Bill, recruits enlisting for the ACF are volunteers who make financial contributions in order to participate. Nevertheless, the Army needs estimates of program costs at the time of enlistment, so that it can allocate funds for the future program costs, and compare the costs of educational benefit programs to other recruiting resources.

This paper provides a methodology for estimating the costs of military educational benefits for an individual at the time of enlistment. A behavioral model of the benefit usage process is developed so that estimates of benefit usage can be made for different kinds of individuals and different programs. An eligible individual's behavior is divided into five key decisions, which can be combined to estimate total benefit usage for an individual with specific characteristics. Also, dividing the process up into separate stages facilitates future projections of benefit use and program costs, since new information, such as changing applicant characteristics, program modifications, or changing retention policies can be used to modify each part of the process, as appropriate.

BACKGROUND

The US Army began using of educational benefits as an enlistment incentive in 1979. The current program, known as the Army College Fund, provides supplemental educational benefits for highly qualified individuals who enlist in difficult-to-fill skills. The program is open to high school graduates who score at the fiftieth percentile or above on the Armed Forces Qualifying Test (AFQT). Qualified individuals must select a program-eligible military occupation in order to receive the supplemental educational benefits, often referred to as "kickers".

In fiscal year 1981, the Office of the Secretary of Defense conducted an experiment with different educational benefits to determine if more effective programs could be developed. Two of the programs tested in the experiment were the Army College Fund and Super VEAP. Super VEAP offered kickers of $2,000 for a two-year enlistment, $4,000 for a three-year term, and $6,000 for a four-year contract were offered.

An experimental program, referred to as Ultra VEAP during the experiment, became the Army College Fund in fiscal 1982. Ultra VEAP was similar to Super VEAP in that soldiers were required to contribute up to $2,700. However, Ultra VEAP offered kickers of $8,000 for a two-year enlistment, and $12,000 above the basic VEAP benefit for either three or four-year terms.

The experiment initially covered about 47 percent of Army positions. Initially 45 military occupational specialties (MOS), primarily in the combat arms, were eligible for benefits. However, because of recruiting difficulties, 20 additional MOS covering an additional 9 percent of enlistment slots were added in February 1981. These new occupations were primarily in support functions such as legal clerk, dental specialist, air traffic control tower operator, and food service specialist. Thus, the experiment consisted of two separate program levels during the course of fiscal year 1981.

An analysis of the enlistment effects of Educational Assistance Test Program was performed by Fernandez (1982). He found the Army College Fund was successful in terms of increasing quality Army enlistments; it also did not appear to draw recruits away from other services. This program was implemented nationally during fiscal year 1982.

What is less certain for the program is its cost. Individuals cannot use benefits until they have completed at least two years of service, and have up to ten years after leaving the military to use the benefits. Therefore, the ultimate cost of the program cannot be known until many years after the benefits are offered. Without estimates of the program costs, it is not possible to assess the program's cost-effectiveness relative to other recruiting resources.

A MODEL OF BENEFIT USE

The usage of special military educational benefits for high quality individuals, often referred to as "kickers", is determined by five factors:

- contribution
- completion of service
- separation
- user status
- benefits spent per user

Benefit usage is determined by the product of all five decisions. An individual must make the appropriate choice at each of the first four decision points to have any benefit use. For example, not all eligible individuals choose to participate in the basic educational benefit program. If the individual chooses not to participate in the Veterans Educational Assistance Program (VEAP), then he or she is not eligible for the kickers. Also, the individual must complete at least 21 months on active duty to become eligible for the kickers. Not all individuals who contribute and complete the required service actively participate in the program. The eligible participant must separate from the military to use the college benefits.

Also, after separation from the Army, the individual then has ten years to use benefits. Thus, recruits who enlisted when the Army College Fund was first tested in 1981 still have many years to use the benefits.

Individuals who entered the Army in fiscal 1981 and who were eligible for either the Army College Fund or Super VEAP were tracked through September 1987 to determine the extent to which they used military educational benefits. Five behavioral models of factors necessary for benefit usage were estimated for this group: contribution behavior, continuation behavior, reenlistment behavior, start of benefit usage, and amount of benefits used per user.

Models were estimated using individual level data on behavior. That is, for each model of choice behavior, individuals were observed as to what their choice behavior was, as well as selected explanatory variables of interest, including individual characteristics and program variables.

Contribution Behavior

Individuals in the two programs had to contribute to the basic VEAP program to be eligible for ACF and Super VEAP kickers. Thus, the first model of educational benefit usage behavior is of this contribution behavior. It is of the form:

P(CONTRIBUTE) = f(X, Program)

where the probability that an individual contributes to the educational benefit program is estimated as a function of individual characteristics (X) and program characteristics.

Table 1 identifies the explanatory variables that comprise the set of individual and program characteristics tested against probability of making contributions. AFQT, age, race, sex, dependents, and whether the individual has had any previous college education are the individual characteristics hypothesized to affect contribution probability. Also, to control for occupational differences, the Department of Defense (DOD) occupational categories were used to identify the kind of specialty for which the individual enlisted.

A set of categorical variables account for both enlistment term and program differences that were available to recruits. The reference program is the ACF three-year enlistment. Additional variables indicate if the individual was under the Super VEAP Program, if a two-year or four-year enlistment was selected, or if an individual under the Super VEAP took either a two-year or four-year enlistment. To control for any variance in behavior over time independent of programs, three quarterly categorical variables were used. The reference time period was the winter of 1981.

Table 2 provides the results from a linear probability regression estimating the probability of an individual contributing to his or her educational benefit fund. Over all two-thirds of the recruits made contributions to their educational benefits account. Most of the human capital related variables were significant with the expected sign. Those with high AFQT scores, young, with previous college, and no dependents were most likely to contribute. Blacks had about 6.5 percent higher contribution probabilities than nonblacks, but women did not differ significantly from men. Recruits in other technical specialties (DODOCC4) had a significantly higher probability of contributing, while those entering equipment repair (DODOCC6) and supply (DODOCC8) specialties were much less likely to contribute.

The Super VEAP Program, with its lower benefit levels, had nearly 13 percent lower contribution rates than the ACF. The two-year enlistment term had an 8 percent higher contribution probability than the three-year enlistment, but somewhat surprisingly, the four-year enlistment did not have significantly lower rates. The interaction term for the Super VEAP four-year

enlistment was positive, indicating that the four-year term under Super VEAP (SVP4) was only about 4 percent lower in its contribution rates than the four-year ACF.

Completion Behavior

A recruit must complete at least 21 months of service to become eligible for benefits. This is essentially the complement of attrition behavior. Hence, the same factors that affect attrition should affect completion probabilities.

Table 3 presents the results of the service completion model. About 83 percent of those who made contributions served the time required to become eligible for benefit usage. Blacks, recruits with high test scores, and long periods in the delayed entry program (DEP) had significantly higher completion rates. In contrast, older recruits and women had much lower completion probabilities than younger male recruits. Those un communication and intelligence (DODOCC2), medical and dental specialties (DODOCC3) and in other technical specialties (DODOCC4) had significantly higher completion rates. The only program variable with a significant relationship to completion rates was the two-year term, which had about 5 percent higher completion rates than the three-year reference group.

Separation Behavior

In order to use educational benefits, individuals must leave the military. Hence, a model of reenlistment behavior is estimated. In addition to the demographic, program, and occupational variables, two economic variables were added. These are the selective reenlistment bonus (SRB) multiplier in effect at the time of reenlistment, and the unemployment rate in the recruits home district during the month he or she completes the first enlistment. Also, the dependents variable was measured at the time of reenlistment.

Table 4 shows the results of the linear probability regression for reenlistment. Most of the demographic variables agree with previous research results and economic theory. High AFQT soldiers have somewhat lower reenlistment rates, while blacks and those with dependents have much higher reenlistment probabilities. Recruits in technical (DODOCC4), administrative (DODOCC5), and supply (DODOCC8) specialties were most likely to reenlist. High SRBs and high unemployment are both associated with significantly higher reenlistments.

The major program effect was found to be associated with enlistment term. Two-year recruits had a nearly 12 percent lower reenlistment rate than three-year term recruits, and four-year term enlistments reenlisted at rates about 5 percent higher.

Three-year term Super VEAP recruits had reenlistment rates about 4 percent higher than ACF recruits, but the differences decreased to about 3 percent for two-year term soldiers, and 2 percent for those enlisting initially for a four-year term.

Start of Benefit Use

Table 5 presents the results of a regression on the probability of using any educational benefits by September 1987. By this time all recruits had at least two years after completion of their initial enlistment to begin benefits. About 30 percent of the sample had used any of their educational benefits.

To control for the time available to use benefits, several variables have been added. MONTH reflects the number of months since the recruit has separated, while MONTH2 is the squared number of months. These two factors can determine if the probability of becoming a user changes with months the recruit has had to begin use. There is over a two year range in time among program participants in which to start using benefits. It is hypothesized that usage should increase with additional time available to use benefits, but increases should level off. Hence the linear term should be positive, but the quadratic term negative. Also, three seasonal variables are provided to control for seasonal differences in the college start rate.

The human capital variables for age, test score, previous college, women, and dependents were all significant and often provided considerable explanatory power. An individual with an AFQT of 99 would have 30 percent greater likelihood of using benefits than someone with an AFQT of 50; a 23 year old recruit would have a 10 percent lower probability of using benefits than an 18 year old enlistee. A recruit with some college was estimated to have a 14 percent greater probability of using benefits, while someone who leaves the service with dependents was 11 percent less likely to use benefits. Those who worked in communications and intelligence were more likely to use benefits, while those who served in equipment repair and supply were much less likely to use benefits.

Program differences in benefit use were substantial. The Super VEAP Program three-year had over 16 percent lower benefit use probabilities than the Army College Fund. Two-year term recruits were 14 percent more likely to use benefits than three-year term recruits, but four-year term enlistments were 12 percent less likely. The lower usage probabilities of Super VEAP recruits dropped to about 9 percent for four-year term recruits, but remained about 16 percent for two-year recruits.

Neither MONTH or MONTH2 was significantly associated with different probabilities of use. This finding indicates that usage rates did not change significantly over the period investigated. However, those soldiers who separated in the summer had a 3 percent greater probability of attending college.

Amount of Benefits Used

Table 6 provides the results for a linear equation for the amount of benefits used as a function of the same factors used in estimating usage probability. About $4,250 had been used by the average benefit user by September 1987. As to be expected, the program variables dominate. A three-year term Super VEAP user had spent over $3,900 less than his ACF counterpart. Both two-year and four-year enlistments had spent less than the three-year recruits.

Both the linear and quadratic terms for time were significant in this case. This indicated that the amount of benefits used was increasing with time, but at a decreasing rate. The maximum amount of benefits used are estimated to occur at abut 47.5 months after the start of benefit usage. Also, recruits starting college in the summer had spent about $600 more than recruits entering during the winter.

DISCUSSION

It is possible to identify many individual and program factors that are associated with behaviors affecting use of educational kickers. Both enlistment term and the kind of program were important indicators of benefit usage. For example, while the level of benefits is important, it is likely that a two-year program will produce greater costs than longer enlistments with much higher benefit levels.

In order to estimate total program costs, it is necessary to forecast both the number of benefit users and the amount used by each. Based on the research performed here, it is unlikely that the number of users would be expected to increase significantly. However, the dollars of benefits used by each can be expected to increase.

Once projections are available of benefit usage by year, it will be possible to produce estimates of the costs incurred by the Army at the enlistment point by discounting benefit use at the appropriate interest rate. These discounted benefits can be combined with enlistment models to compare the costs of educational benefit kickers to other resources, such as bonuses for recruiting individuals.

REFERENCES

Fernandez, R.L. (1982). Enlistment effects and policy implications of the Educational Assistance Test Program (R-2935-MRAL). Santa Monica, CA: Rand Corporation.

Table 1

Definition of Variables

Variable	Definition
AFQT44	AFQT percentile score, 1944 metric
EAGE	Age at enlistment, in years
FEMALE	1 if female, 0 otherwise
HIGHED	1 if one or more years of college completed, 0 otherwise
DEPEND	1 if marital status other than single with no dependents
BLACK	1 if black, 0 otherwise
UNEMP	unemployment rate in recruiting district during quarter of separation
SRBMULTP	SRB multiplier for job at time of term completion
SUPERVP	1 if Super VEAP benefits available to recruit, 0 otherwise
TWOYEAR	1 if recruit selects two-year term, 0 otherwise
FOURYEAR	1 if recruit selects four-year term, 0 otherwise
SVP2	1 if Super VEAP and two-year term selected, 0 otherwise
SVP4	1 if Super VEAP and four-year term selected, and 0 otherwise
DEP	months in the Delayed Entry Program
DODOCC1	1 if job is in DODOCC1- electronic equipment repair
DODOCC2	1 if job is in DODOCC2- communications and intelligence
DODOCC3	1 if job is in DODOCC3- medical and dental specialties
DODOCC4	1 if job is in DODOCC4- other technical specialties
DODOCC5	1 if job is in DODOCC5- administrative
DODOCC6	1 if job is in DODOCC6- electrical/mechanical equipment repair
DODOCC7	1 if job is in DODOCC7- craftsmen
DODOCC8	1 if job is in DODOCC8- service and supply handlers
DODOCC9	1 if job is in DODOCC9- missing data
DEC80	1 if recruit enlisted during Dec 1980-Jan 1981, 0 otherwise
SPRING81	1 if recruit enlisted during Mar-Jun 1981, 0 otherwise
SUMMER81	1 if recruit enlisted during Jul-Sep 1981, 0 otherwise

Table 2

Regression Results for Contribution Behavior Equation

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	22	269.10348	12.23197647	60.350	0.0001
ERROR	13517	2739.67429	0.20268360		
C TOTAL	13539	3008.77777			

ROOT MSE	0.450204	R-SQUARE	0.0894
DEP MEAN	0.6666913	ADJ R-SQ	0.0880
C.V.	67.5281		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	0.75800013	0.03887327	19.499	0.0001
AFQT44	1	0.004105851	0.000304496	13.484	0.0001
EAGE	1	-0.01429861	0.001552064	-9.213	0.0001
FEMALE	1	0.01299132	0.01159855	1.120	0.2627
HIGHED	1	0.06565678	0.01273631	5.155	0.0001
DEPEND	1	-0.16921794	0.01239405	-13.653	0.0001
BLACK	1	0.06489167	0.01323696	4.902	0.0001
TWOYEAR	1	0.08209539	0.01949828	4.210	0.0001
FOURYEAR	1	-0.007578319	0.01852896	-0.409	0.6825
SUPERVP	1	-0.12927417	0.01539790	-8.396	0.0001
SVP2	1	-0.01132599	0.02367751	-0.478	0.6324
SVP4	1	0.08558344	0.02016288	4.245	0.0001
DODOCC1	1	0.04823169	0.05360129	0.900	0.3682
DODOCC2	1	0.01302059	0.01081288	1.204	0.2285
DODOCC3	1	0.03763681	0.03881429	0.970	0.3322
DODOCC4	1	0.07669196	0.02967385	2.584	0.0098
DODOCC5	1	-0.006154494	0.01595206	-0.386	0.6996
DODOCC6	1	-0.14274730	0.02131269	-6.698	0.0001
DODOCC8	1	-0.15843948	0.01383828	-11.449	0.0001
DODOCC9	1	-0.13406609	0.01634288	-8.203	0.0001
DEC80	1	-0.06358287	0.02076017	-3.063	0.0022
SPRING81	1	-0.008552324	0.01067682	-0.801	0.4231
SUMMER81	1	0.009297966	0.009074851	1.025	0.3056

Table 3

Regression Results for Completion Behavior Equation

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	23	54.99608803	2.39113426	17.689	0.0001
ERROR	9003	1217.00347	0.13517755		
C TOTAL	9026	1271.99956			

ROOT MSE	0.367665	R-SQUARE	0.0432
DEP MEAN	0.8302869	ADJ R-SQ	0.0408
C.V.	44.28168		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	0.91809319	0.04311746	21.293	0.0001
AFQT44	1	0.000776537	0.000300562	2.584	0.0098
EAGE	1	-0.008586402	0.001707517	-5.029	0.0001
FEMALE	1	-0.12710092	0.01181541	-10.757	0.0001
HIGHED	1	0.02281700	0.01247899	1.828	0.0675
DEPEND	1	0.01772444	0.01418873	1.249	0.2116
DEP	1	0.006781847	0.001512528	4.484	0.0001
BLACK	1	0.07248688	0.01306402	5.549	0.0001
TWOYEAR	1	0.05278607	0.01838135	2.872	0.0041
FOURYEAR	1	-0.02071434	0.01796823	-1.153	0.2490
SUPERVP	1	0.02020892	0.01570072	1.287	0.1981
SVP2	1	-0.01940089	0.02319347	-0.836	0.4029
SVP4	1	0.005050314	0.02011407	0.251	0.8018
DODOCC1	1	0.06161809	0.04932239	1.249	0.2116
DODOCC2	1	0.03247361	0.01037300	3.131	0.0018
DODOCC3	1	0.07529358	0.03632191	2.073	0.0382
DODOCC4	1	0.05562744	0.02755744	2.019	0.0436
DODOCC5	1	0.01964625	0.01570020	1.251	0.2108
DODOCC6	1	0.01346264	0.02291770	0.587	0.5569
DODOCC8	1	-0.006354658	0.01443970	-0.440	0.6599
DODOCC9	1	-0.17821633	0.01741091	-10.236	0.0001
DEC80	1	-0.01608228	0.02198891	-0.731	0.4646
SPRING81	1	0.004572610	0.01132496	0.404	0.6864
SUMMER81	1	-0.006384715	0.009267298	-0.689	0.4909

Table 4

Regression Results for Reenlistment Behavior Equation

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	24	193.81665	8.07569374	46.247	0.0001
ERROR	7416	1294.99050	0.17462116		
C TOTAL	7440	1488.80715			

ROOT MSE	0.417877	R-SQUARE	0.1302
DEP MEAN	0.2765757	ADJ R-SQ	0.1274
C.V.	151.0895		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	0.17520887	0.05418545	3.234	0.0012
AFQT44	1	-0.001096375	0.000379653	-2.888	0.0039
EAGE	1	0.002538582	0.002171230	1.169	0.2424
FEMALE	1	0.06252191	0.01560642	4.006	0.0001
HIGHED	1	-0.03791849	0.01571311	-2.413	0.0158
DEPEND	1	0.08572181	0.01810131	4.736	0.0001
BLACK	1	0.14920625	0.01619272	9.214	0.0001
UNEMP	1	0.004226904	0.002076817	2.035	0.0419
SRBMULTP	1	0.01518925	0.004633126	3.278	0.0010
TWOYEAR	1	-0.11948834	0.02293036	-5.211	0.0001
FOURYEAR	1	0.05393100	0.02279543	2.366	0.0180
SUPERVP	1	0.04436092	0.01998027	2.220	0.0264
SVP2	1	-0.01442364	0.02880222	-0.501	0.6165
SVP4	1	-0.02202711	0.02552856	-0.863	0.3883
DODOCC1	1	0.02707749	0.05985771	0.452	0.6510
DODOCC2	1	0.02338671	0.01289907	1.813	0.0699
DODOCC3	1	0.05797716	0.04410946	1.314	0.1888
DODOCC4	1	0.08522621	0.03329736	2.560	0.0105
DODOCC5	1	0.09884940	0.01989783	4.968	0.0001
DODOCC6	1	0.01639224	0.02852395	0.575	0.5655
DODOCC8	1	0.04579329	0.01838846	2.490	0.0128
DODOCC9	1	0.56994668	0.02444764	23.313	0.0001
DEC80	1	-0.07429607	0.02732033	-2.719	0.0066
SPRING81	1	-0.02759467	0.01358895	-2.031	0.0423
SUMMER81	1	-0.02054439	0.01131276	-1.816	0.0694

Table 5

Regression Results for Start of Benefit Use Equation

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	25	213.27606	8.53104245	46.538	0.0001
ERROR	7392	1355.04855	0.18331285		
C TOTAL	7417	1568.32462			

ROOT MSE	0.4281505	R-SQUARE	0.1360
DEP MEAN	0.3035859	ADJ R-SQ	0.1331
C.V.	141.0311		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	0.52764542	0.07757653	6.802	0.0001
AFQT44	1	0.006060371	0.000392175	15.453	0.0001
EAGE	1	-0.02122449	0.002094929	-10.131	0.0001
FEMALE	1	-0.06782207	0.01677284	-4.044	0.0001
HIGHED	1	0.13607973	0.01647812	8.258	0.0001
DEPEND	1	-0.11444736	0.01200435	-9.534	0.0001
BLACK	1	-0.02834602	0.01851552	-1.531	0.1258
TWOYEAR	1	0.13563614	0.02533832	5.353	0.0001
FOURYEAR	1	-0.11597799	0.02507682	-4.625	0.0001
UNEMP	1	0.001294431	0.002302523	0.562	0.5740
SUPERVP	1	-0.16642331	0.02046338	-8.133	0.0001
SVP2	1	-0.007783655	0.02872662	-0.271	0.7864
SVP4	1	0.07309024	0.02691543	2.716	0.0066
MONTH	1	-0.002456819	0.003094881	-0.794	0.4273
MONTH2	1	-0.000018506	0.000042051	-0.440	0.6599
DODOCC1	1	-0.11386035	0.06603521	-1.724	0.0847
DODOCC2	1	0.04591856	0.01342872	3.419	0.0006
DODOCC3	1	0.03123350	0.04915181	0.635	0.5252
DODOCC4	1	0.04852430	0.03632999	1.336	0.1817
DODOCC5	1	0.007056374	0.02035423	0.347	0.7288
DODOCC6	1	-0.05395368	0.02571166	-2.098	0.0359
DODOCC8	1	-0.09467303	0.01688786	-5.606	0.0001
DODOCC9	1	-0.03766951	0.05137017	-0.733	0.4634
SPRING	1	0.004452431	0.01527269	0.292	0.7707
SUMMER	1	0.03394375	0.01415227	2.398	0.0165
FALL	1	-0.001522528	0.01699819	-0.090	0.9286

Table 6

Regression Results for Amount of Benefits Used Equation

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	25	9938811814	397552473	71.393	0.0001
ERROR	2226	12395428216	5568476.29		
C TOTAL	2251	22334240030			

ROOT MSE	2359.762	R-SQUARE	0.4450
DEP MEAN	4257	ADJ R-SQ	0.4388
C.V.	55.43251		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	2246.05221	680.07942	3.303	0.0010
AFQT44	1	22.22649868	3.89630347	5.705	0.0001
EAGE	1	-129.55004	25.26924191	-5.127	0.0001
FEMALE	1	-164.99479	186.52501	-0.885	0.3765
HIGHED	1	564.01345	151.06959	3.733	0.0002
DEPEND	1	-64.22287685	145.85470	-0.440	0.6597
BLACK	1	-468.70805	215.50355	-2.175	0.0297
TWOYEAR	1	-699.46046	228.11798	-3.066	0.0022
FOURYEAR	1	-1037.15494	229.24969	-4.524	0.0001
UNEMP	1	14.98147091	23.11201320	0.648	0.5169
SUPERVP	1	-3906.90233	202.83989	-19.261	0.0001
SVP2	1	-403.87730	265.32489	-1.522	0.1281
SVP4	1	1847.58907	267.08691	6.918	0.0001
MONTH	1	254.84474	23.90698514	10.660	0.0001
MONTH2	1	-2.68206813	0.39431149	-6.802	0.0001
DODOCC1	1	-655.40219	754.21000	-0.869	0.3849
DODOCC2	1	-127.51661	126.91748	-1.005	0.3151
DODOCC3	1	444.83006	467.78676	0.951	0.3417
DODOCC4	1	-142.80105	325.01673	-0.439	0.6604
DODOCC5	1	-402.28991	192.78733	-2.087	0.0370
DODOCC6	1	-159.74390	268.87148	-0.594	0.5525
DODOCC8	1	20.73969109	172.94118	0.120	0.9046
DODOCC9	1	-224.42045	540.05052	-0.416	0.6778
SPRING	1	153.28829	198.59750	0.772	0.4403
SUMMER	1	593.21450	112.42126	5.277	0.0001
FALL	1	333.67398	241.81930	1.380	0.1678

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EVALUATING IMPROVEMENTS TO

MOS ASSIGNMENT POLICY

Edward Schmitz

Roy Nord

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REVIEWED BY: Abraham Nelson APPROVED BY: Curtis L. Gilroy

U.S. Army Research Institute
for the Behavioral and Social Sciences
5001 Eisenhower Avenue, Alexandria VA 22333

I. INTRODUCTION

A critical decision in the Army's personnel system is the allocation of non-prior service recruits to military occupational specialties (MOS) for training. This assignment decision determines how wisely several billion dollars in human capital are invested, and the performance and capabilities of the Army are directly affected by how well it is made.

This paper discusses the improvements to the assignment process that can now be achieved by implementing results of ARI classification and assignment research. We present results from simulations designed to assess the potential benefits of improving the classification and assignment of non-prior service accessions to training MOS. The simulations indicate that the gains in productivity that could be achieved by more efficiently allocating currently available manpower are equivalent to those that would be expected from an increase of about 25% in high-quality accessions.

The next section provides a review of relevant previous research in the areas of psychology, economics, and operations research. Section III describes the approach used to develop simulations of the impact of improvements in the assignment process, while section IV presents the simulation results. Section V provides cost-benefit assessments of the results using both psychological and economic models. Policy implications are discussed in the final section.

II. LITERATURE REVIEW

Psychologists have long recognized the relationship between improvements in the prediction of job performance and organizational productivity. The origins of research into this relationship can be traced to work by Taylor and Russell (1939) and Brogden (1949). Recently there has been a refinement to and extension of these ideas to apply them to employee selection in both the public and private sectors (see, e.g. Schmidt and Hunter (1985), and Cronbach and Gleser (1965)).

A key innovation from Brogden was the development of an equation for evaluating the impact of a selection test on organizational productivity. His equation took the form:

$$U = N\ v\ SD_y\ Z \qquad (1)$$

where U is the gain in organizational productivity;

v is the validity of the predictor (correlation with the performance criterion);

N is the number of individuals selected;

SD_y is the value to the organization of one standard deviation increase in performance; and

Z is the expected mean predictor score (expressed in standard normal deviations) resulting from a given selection standard.

This formula provided a systematic way to assess the impact of selection tests. For a considerable time, however, very little work was performed in this area, primarily because of the perceived difficulty of assigning a dollar value to a standard deviation in performance. Cost accounting information and personnel records did not generally lend themselves to empirical estimation of the relationship between output and performance (Cronbach and Gleser 1965). Schmidt and Hunter (1982) were only able to find two studies where cost accounting procedures were used to measure SD_y.

Eventually, advances in techniques for the collection and interpretation of survey data led to the use of expert judgments of the dollar value of performance (Schmidt and Hunter 1982). This approach relies on assessments elicited from individuals in a position to evaluate the organizational consequences of variations in job performance. These individuals are asked to estimate the dollar value of selected levels of performance. By imposing distributional assumptions on both the error in these judgments and the variations in job performance it is possible to arrive at estimates of the dollar value of a standard deviation in performance. This approach has also been used to obtain nonmonetary valuations of output by Eaton et al. (1985).

Recent research by Schmidt et al. (1985) has shown that, in a wide variety of such surveys, the estimates of the value of a standard deviation of performance tend to fall in the range of 40 to 70 percent of salary. This finding has led to widespread use of a "rule of thumb" of 40% of salary as a conservative estimate of the value of a standard deviation change in expected mean performance.

Economic Approaches to Selection Evaluation

A related approach for estimating the value of improved selection comes from the economic literature. Under economic theory of production it can be shown that in a competitive situation an employer will set the wage rate equal to the marginal product or output of the worker (Ehrenberg and Smith 1982). The idea is that the employee's wage should directly reflect his or her productivity.

If this theoretical prediction is reflected in practice, we would expect that a competitive firm should be willing to pay a price differential equal to the value of the increase in marginal product resulting from improved job performance. If the performance improvement is achieved through more efficient selection, then one measure of the value of the selection procedure is this "willingness to pay".

Under this approach the dollar value of improved performance will depend on the rate at which improved performance is translated to increased organizational output (the "output elasticity" of performance) and on the value (or price) of output. Interestingly, a value of 40 percent of salary would imply an output elasticity of performance of approximately .59.

The degree to which this theoretical prediction is reflected in practice has been questioned by several economists. Thurow (1975), while generally acknowledging that this concept would hold in the aggregate, argues that it may not be applicable for any specific group of employees. Frank (1984), in an empirical analysis of employee output in selected occupations where marginal output could be reasonably measured, found that the most productive workers tended to be underpaid while the least productive members were overpaid. The issue is further complicated in the public sector, where the quantity of output is often difficult to measure and measurement of output in dollar terms is virtually impossible.

An alternative economic approach to evaluating the costs and benefits of employee selection was provided by Armor et al. (1982). This approach focuses on "opportunity costs" as a measure of the value of a selection procedure. In effect, this method argues that the value of achieving a given improvement in performance through more effective selection, classification and assignment procedures is at least equal to the cost of achieving the same improvements by lowering the selection ratio. This approach differs from earlier psychological utility models in two ways.

The first major difference is its recognition that increased selectivity imposes costs other than those involved in designing and administering the selection instrument. Most of the psychological models of selection utility either implicitly or explicitly assume that the number of job applicants is infinite, and thus the only costs associated with increased selectivity are those required to develop the instrument and process applicants. Armor explicitly assumed that

productivity gains from higher job standards would require higher recruiting costs. Thus, the model examines the impact of setting standards from an organizational perspective; tradeoffs are made directly between job performance and personnel costs.

The second difference was the use of time as a component of job performance value. A measure was constructed that included both technical job performance and employee turnover. This indicator, "qualified man months", weights the probability that a selected recruit will perform at or above a given standard by the expected duration of that level of performance.

The Classification and Assignment Problem

The primary focus of the literature discussed above has been on the identification and evaluation of procedures for the selection of candidates from a pool of potential employees. The classification and assignment problem is concerned with the optimal allocation of the selected population to a number of jobs with differing requirements. In order to solve this problem, two issues must be accomplished: First, it must be possible to differentially predict performance in the set of jobs under consideration -- the classification problem. Second, this information must be efficiently used to match candidates with jobs -- the assignment problem.

The classification and assignment problem is considerably more complex than is the selection problem for two reasons: First, the "ideal" classification instrument must not only be able to accurately predict job performance, but also be able to predict those aspects of job performance that are unique to a particular job. That is, in classification we are concerned not only with the validity of the predictors but also with the intercorrelations among the predictions. Second, and perhaps more important, the development of an optimal classification procedure cannot be divorced from the choice of a method for implementing that procedure -- that is, classification and assignment must be considered jointly. Furthermore, as we shall see, unless extremely restrictive and unrealistic assumptions are imposed, the optimal assignment problem will not have a closed form solution. This means that it is at best very difficult to derive a simple criterion for evaluating alternative classification instruments without the use of simulation techniques.

In part because of these complexities, and in part because, for many organizations, classification is less important than selection, the literature on classification and assignment is much more sparse than that on selection. In addition, with only occasional exceptions (e.g., Dwyer, 1954) the research has dealt with the problem in a piecemeal fashion. The personnel psychology literature deals primarily with the hypothetical problem of evaluating alternative classification procedures in the abstract, imposing heroic assumptions to do so. The literature on optimal assignment, on the other hand, has tended to focus on the mathematical mechanics of the problem, ignoring the issue

of obtaining the information required to construct the objective function.

Most of the classification research in the psychology literature is again based on the original work of Brogden (1959). In order to derive an equation for assessing the effect of classification on expected job performance, Brogden imposed the following assumptions:

(1) The number of people to be assigned is infinite.

(2) All jobs are equal in size.

(3) The job-specific predictors of performance are distributed multivariate normal with constant mean and variance in the population from which the pool to be assigned is selected.

(4) Both the validities of job-specific predictors and their intercorrelations are equal (or can be reasonably approximated by their means).

(5) Performance is equally valuable (has equal utility) in all jobs.

Given these assumptions, Brogden showed that the optimal assignment policy is to place each candidate into the job for which he or she has the highest predicted performance. Finally, given this policy, he derived a formula for calculating the "allocation average" (P) for a given classification instrument:

$$P = v\,(1-r)^{1/2}\;k \tag{2}$$

where v is the (mean) predictor validity

r is the (mean) correlation between the predictors

k is the expected value of the highest predictor score for a randomly chosen individual from the selected population.

In effect, k is the expected value of the first-order statistic in a sample of size n from a lower-truncated standard normal population, where n is the number of jobs or job categories. Note that k will increase with the number of job categories, which increases the size of the sample from which the order statistic is drawn, and decrease with the selection ratio, which determines the degree of truncation of the original standard normal population.

This formula, while apparently simple, describes a complex nonlinear relationship among the three factors that determines the allocation average. It is easy to see the effect of changes in any one factor, given that the other two factors are held constant:

$$\frac{dP}{dv} = k(1-r)^{1/2}$$

$$\frac{dP}{dr} = -.5vk(1-r)^{-1/2}$$

$$\frac{dP}{dk} = v(1-r)^{1/2}$$

Since v, k, and r are all nonnegative, the allocation average will increase with increases in validity, decrease with increases in the intercorrelation of the job predictors, and increase with increases in the number of job categories. Unfortunately, in practice these components are not independent of each other. Simply increasing the number of job categories without a corresponding change in the predictor battery will tend to increase the intercorrelation of the predictors, for instance. The formula does, however, provide a way of determining whether a given set of changes in the three factors will yield an increase in the allocation average (under the assumptions set out above).

The economics and operations research literatures have tended to focus on aspects of the assignment as opposed to the classification problem. For the most part, economists have been concerned with the optimal allocation of resources -- either among various inputs to the production process, including different "quality levels" of the labor force, or among the activities within an organization (usually assumed to be a competitive firm) that must compete for those inputs. While this literature has much to contribute to the problem of evaluating selection and classification systems, it has not focused much attention on the issues of performance measurement and prediction that are central to the classification problem.

The operations research field has focused a great deal of attention on the development of efficient algorithms for maximizing the value of a set of assignments, subject to a complex network of constraints, given a known, non-stochastic set of "payoffs" for every permissible assignment. Most of the applications of this work have been directed toward problems other than personnel allocation (transportation, scheduling, plant location, etc.) but there have been a number of personnel applications.

Dwyer (1954) showed how the personnel assignment problem could be solved as a linear programming problem. Schmitz and Nelson (1984) and Fernandez (1985) applied linear programming techniques to the military classification problem. These applications illustrate the tradeoffs inherent in the optimal assignment approach: First, the introduction of realistic inequality constraints results in a problem that does not have a general closed-form solution. A second and related limitation is that practically feasible programming techniques assume that all parameters are deterministic. (Stochastic programming techniques are available, but impractical for large applications.) This means that, outside of quite narrow limits, it will not be possible to predict the effect of variations in the composition of the population being assigned, or of changes in the parameters of the problem. Finally, and most importantly, these techniques assume that all assignments can be made at once -- that the entire population can be assigned to the entire set of jobs in a single "batch" operation.

The first two of these limitations can be largely overcome by a combination of simulation and sensitivity analyses. Using these

techniques, a variety of alternative classification systems operating in different environments can be evaluated and compared. The results of such simulations will represent the maximum level of predicted performance that could be obtained from a given population. However, to the extent that assignments made sequentially deviate from those "recommended" by the batch solution, the simulation results will overstate the payoffs actually achieved.

A second line of research in the operations research and management science literature has focused on the search for "optimal decision rules" under minimally restrictive assumptions about the distribution and variability of predicted performance in the population. This work deals with the class of problems known generically as the "secretary problem" (Tamaki 1984). A position must be filled from a set of candidates who are evaluated sequentially. It is assumed that expected performance can be determined when a candidate is observed, but that the distribution of performance in the population is initially unknown. These assumptions are analogous to a situation where the parameters of the distribution of expected performance in the population are known but unpredictable over time. An "optimal" rule will be one that maximizes the probability of selecting the highest ranked candidate or candidates. Unfortunately, this line of research is of little practical relevance because its focus on minimizing *a priori* assumptions. The classification problem results in a very complex decision rule even when dealing with as few as three assignments.

Less complicated decision-rule approaches have been frequently used for placing recruits into job training by the military. Examples of such systems are provided by Kroeker and Rafacz (1983) for Navy rating assignment and Ward (1978) for Air Force specialty training. While such decision rule approaches provide reasonable and flexible approaches to job assignment, they will, in general, result in allocations that are markedly inferior to those that would be recommended by an optimal assignment algorithm.

III. APPROACH

ARI is currently pursuing an effort to improve both the validity and precision of the information provided by the Army's selection and classification system and the effectiveness with which that information is used represents a composite of the various approaches described above. The Enlisted Personnel Allocation System (EPAS) uses forecasts of the distribution of predicted performance in an optimal assignment algorithm to produce recommendations that guide a sequential rule-based assignment system. The assignment system is designed to make maximum use of improvements in selection and classification instruments. Concurrently, the development of new predictor composites will use EPAS simulations as well as more traditional tools to evaluate their potential for enhancing productivity.
A description of EPAS is provided in Schmitz and McWhite (1986).

Figure 1 illustrates the basic structure of EPAS. The three top boxes comprise the planning subsystem. This portion of EPAS develops

strategies for matching categories of candidates with job openings over a twelve-month period. Recruits usually enter the Delayed Entry Program to wait for assignment to training. Individuals may be assigned to training as much as a year in advance. The planning subsystem uses this flexibility in the recruiting process to synchronize the flow of recruits into jobs with forecasted irregularities in the supply of qualified applicants over a twelve-month time horizon.

The second part of the system is the applicant classification subsystem. This component of the system is designed to accommodate the fact that actual assignments are sequential. The decision algorithm used by the applicant classification subsystem is similar to that used by the other services, but it incorporates one important piece of new information -- a set of weights provided by the planning subsystem that adjusts the sequential decisions to reflect forecasted variations in demands and supplies.

The remainder of this paper will describe the procedure used to assess the potential benefits of one proposed modification of the current classification system. We will present results showing the expected effects of implementing a new set of predictor composites under both the current assignment system and under a new system using the EPAS to aid in assignment decisions. We will also compare the predictions resulting from the EPAS simulations with those produced by applying Brogden's approach for assessing the allocation average.

The Army's Selection, Classification and Assignment Problem

The Army typically recruits 130,000 soldiers each year for training in 275 different military occupational specialties (MOS). The Army spends over 600 million dollars recruiting these soldiers, 1.5 billion dollars providing initial skill training, and over 5 billion dollars in pay and allowances over their first term of service.

Recruits are initially selected from the applicant pool on the basis of Armed Forces Qualification Test (AFQT) scores, as well as educational, physical, and moral standards. The Army is statutorily prohibited from recruiting individuals who score in the bottom 15 percent of the AFQT distribution. In practice, an approximate selection ratio of about .7 is used. In 1984 this resulted in a mean AFQT score of 56.4 among the recruit population.

Classification and assignment to MOS is performed prior to the applicant's acceptance into the military and usually several months prior to entering active duty. The current classification system uses a set of nine aptitude area composites of subtests in the Armed Forces Vocational Aptitude Battery (ASVAB) to predict performance in nine job families. (Three of these subtests are also used to create the AFQT score.) The aptitude area composites are scored so as to be normally distributed with a mean of 100 and a standard deviation of 20 in the youth population. The nine composites have an average intercorrelation of .828 in the assignment population, and an average validity of .607.

The average aptitude area score across all nine composites for the 1984 recruit population was 106.71.

In addition to initial selection on the basis of AFQT score, the Army also imposes minimum qualifying scores on the aptitude area composite associated with each MOS. Because these scores are relatively low, they have little or no effect on the overall selection ratio (That is, very few recruits who would be selected on the basis of their AFQT scores fail to meet the minimum standard for every MOS.) but they do have an effect on job assignment among the selected population by making some selected recruits ineligible for some jobs. This effect is most noticeable among recruits scoring below the 50th percentile on the AFQT. Table 1 provides the distribution of qualifying scores across jobs.

Design of Simulation Scenarios

A new set of six aptitude area composites has recently been developed by Wise and Grafton (1987). The new composites have the a higher validity (.627) and lower intercorrelation (.824) than the current set of nine composites. Our objective is to determine (a) whether or not the increased validity and lower intercorrelation of the new composites will produce overall improvements in expected performance sufficient to offset the effect of reducing the number of composites used; and (b) the magnitude the differences, measured both in terms of relative improvements in expected performance and in terms of estimated dollar value.

In order to accomplish this, we simulated the assignment of the 1984 recruit population under four hypothetical placement policies:

1. Random Assignment. Selected candidates are randomly placed into jobs. There is no attempt to use classification information.

2. Optimal Placement. Candidates are assigned as a batch to jobs using an optimal assignment algorithm that maximizes expected performance while filling all job requirements.

3. Maximum Placement. Candidates are placed into jobs for which they have the highest predicted performance. Specific job requirements are ignored.

4. Operational Assignment. The EPAS is used to simulate the assignments that would result if candidates were assigned sequentially with guidance from an optimal assignment algorithm to meet time-specific job requirements.

The first three scenarios are included to allow us to explore the theoretical potential of the proposed changes and compare estimates of that potential obtained from different methods. The "random assignment" policy provides a baseline against which comparisons can be made. The "maximum placement" policy provides a corresponding "ceiling" in that it represents the absolute maximum predicted performance that could be obtained from this population. This policy

is expected to provide results similar to Brogden's estimate of the potential gains in the allocation average. The "optimal assignment" value will provide an assessment of the level of performance that could be achieved with this population while meeting actual MOS demands, if all recruits could be simultaneously evaluated and assigned. The difference between "maximum" and "optimal" placement will indicate the degree to which Brogden's assumptions result in an overestimate of the potential gains.

The fourth scenario will provide an estimate of the actual impact on organizational productivity under operational conditions. Note, however, that this scenario assumes that applicants will enter the jobs to which they are assigned.

Data

The population assigned in the simulations was a random sample of 5000 recruits from 1984 Army accessions. The sample had the following distribution of characteristics:

Test Category	Number	Percent	Aptitude Area Score
I-IIIA	3120	62.4	113.9
IIIB	1393	27.9	101.1
IV	487	9.7	95.1

IV. RESULTS

The Current System

The Army's current assignment system produced an average aptitude area score of 108.47 for the job a recruit was actually assigned. Table 2 shows the distribution of aptitude area scores by job family. The predictor gain over random assignment was 1.76 points or .088 standard deviations.

There are several reasons for this relatively small increase over a random assignment policy. First of all, the operational system is dominated by concerns other than maximizing job performance. The majority of emphasis is placed upon filling requirements. A high penalty in terms of wasted training resources and lower organizational productivity is paid by the Army if it fails to fill available training seats. In addition, the Army has restrictions on which MOS women may enter and the number who may enter many occupations, as well as AFQT distributional requirements for all MOS to insure that no job is entirely filled with minimally qualified individuals. Thus, with the uncertainties of a sequential placement system, high weight is placed upon simply filling all job demands.

Largely because of these considerations, classification information has little effect on decisions in the present system. Test scores tend

to be used primarily to assure that assignees meet minimum job standards. Given that most candidates greatly exceed most job qualifying scores, this role does little to maximize expected job performance.

Simulation Results

Table 3 shows the estimated predictor gains for the four simulation scenarios described above. For comparison, the observed mean predictor level under the current system and the estimated gains from the Brogden formula are also provided.

The Brogden estimates are, as expected, approximately equal to those produced by the maximum placement policy. Neither is feasible however, since both violate the requirement of filling all the training slots. The highest predictor scores for the assigned population that could theoretically be achieved while filling all jobs are those given by the optimal assignment policy.

The results of the operational assignment simulation show that, while the average predictor score that could be achieved in practice is somewhat lower than that resulting from the theoretical scenarios, the expected gain over the current system achieved by using the new composites under EPAS is 5.03. This represents a gain nearly four times the difference between the current system and a policy of random assignment of the recruit population.

Table 4 presents the expected changes in criterion scores for the two sets of composites under consideration. The theoretical gains in performance from the two composites are very close. For example, if one used the results from the maximum placement approach one would prefer the nine composite set. However, adding the constraint of filling the Army's actual job distribution makes the six composite set preferable.

The new composites produce some gain in expected performance, largely due to their higher validity. However, the improvement becomes much greater when the new composites are implemented along with improvements to the assignment system. The total gains in predicted performance due to both changes would amount to .119 standard deviations in average predicted performance.

V. ESTIMATING THE VALUE OF PRODUCTIVITY GAINS

Psychological Model of Productivity Evaluation

Boudreau and Berger (1985) have examined the application of utility analysis to organizational productivity and recommended an approach that we will adapt here to provide one estimate of the value of potential gains. They argue that the proper use of estimated dollar values for a standard deviation of performance requires that a number of factors other than the estimates themselves be taken into account. These include:

- o the average length time over which the performance will be provided
- o compensation over that period
- o the discount rate
- o projected salary increases over the relevant period

The time period we will use here is the average length of first-term service. Most soldiers do not serve beyond the initial term. Further, it is assumed that reenlistment decisions are made primarily on the basis of observed performance, not performance predicted at the entry point.

The average enlistment term in 1984 was 3.267 years. However, about 36 percent of recruits would be expected to leave prior to completing their enlistment. If we Assume that the time served by attritees is nonproductive, the average productive enlistment is 2.09 years per accession, or 64 percent of the average enlistment.

There are many different estimates of salary for military personnel, since housing and subsistence allowances are separate from basic pay. One frequently used measure of salary is regular military compensation (RMC), which includes basic pay, basic allowances for subsistence and quarters, variable housing allowance, and the tax advantage that comes from tax-free allowances. The following figures for RMC and salary progression were used:

E-1	.33 years	$11,725
E-2	.67 years	$13,804
E-3	1.00 years	$14,765
E-4	1.27 years	$16,425

The above rank progression would result in an average RMC of $48,686 over the average 3.267 year enlistment term.

The discount rate and the salary growth rate affect the present value of salary. We assume a discount rate of 8.5 percent and a salary growth rate of 4 percent. These produce a net discount rate of 4.5 percent is the resulting factor. Applying this rate to the projected RMC stream yields a discount multiplier of .904.

The 40 percent of salary used by Schmidt et al. (1985) is assumed as the relationship of salary to SD_y. Combining all of the above factors, the estimate of the standard deviation in dollars can be estimated as $48,686 * .64 * .904 * 40% = $11,267.

Using this procedure, the dollar value of the gains from ARI's improvements to the assignment system become:

$7.3 million for implementing the new composites with the existing assignment system.

$174.3 million for implementing the new composites with EPAS.

The Economic Opportunity Cost of Productivity Gains

A second approach to evaluating the benefits of improved MOS assignment focuses on the "opportunity costs" of retaining the current system. The new composites and assignment procedure will raise performance by the amounts estimated above. This performance increase could also be achieved under the present system by simply recruiting more high quality soldiers and fewer individuals in test categories IIIB and IV. The expected cost of recruiting these additional I-IIIAs can be used as a measure of the value of the performance gains from improved classification and assignment.

The performance gains that would result from the introduction of the six composites would require increasing the average aptitude area score of our sample by .16 points. This increase could be accomplished by replacing 133 category IV recruits with category IIIB soldiers.

The combined impact of making changes to the composites along with introducing EPAS would require much larger increases in accession quality. In order to raise the average aptitude area score of assigned soldiers by the required 3.92 points one would need to recruit 88.2 percent category I-IIIAs and the no category IVs. This would be an increase of 25.8 percent additional category I-IIIAs.

Projected out to an accession population of 130,000, these quality mix changes become very dramatic. The performance gains of introducing the new composites would be equivalent to recruiting 3,450 more IIIBs and the gains from introducing new composites with EPAS would require 33,500 additional I-IIIAs. There are no reliable figures as to what these quality increases would cost to achieve with additional recruiting resources. However, one assumption is that additional IIIBs would cost about the same as the average recruit costs-- or about $2,350 (from the OMA and MPA Cost Factors, Office of the Comptroller 1984). This would produce a cost equivalent of 8.1 million dollars for the value of introducing the new composites.

Considerable research has been performed on the resources required to recruit I-IIIAs. One recent estimate comes from the enlistment bonus experiment. Polich et al. (1986) estimate that it would cost about $16,000 for each additional high quality recruit obtained with bonuses. Using this figure, the value of performance gains resulting from EPAS would be valued at 536 million dollars.

VI. DISCUSSION

The analysis performed here has provided several useful findings with implications both for how improvements to the assignment process should be developed, and their utility once implemented.

The results suggest that the use of simulation techniques as part of the process of developing new predictor composites is promising. The population relevant to classification is the population assigned by the Army. The general youth population includes both many low aptitude

people who would fail to meet enlistment standards, and high aptitude youths who do not apply. Simulations of assignments should be performed with several sample populations of recruits that might be obtained in different recruiting environments.

Secondly, the evidence provided here indicates that job demands do matter. Since MOS requirements are not evenly distributed across aptitude areas, simulations such as those performed here will usually yield different results than those provided by correlational techniques. Such an approach will aid in the formation and choice of composites.

ARI's research in classification and assignment can be very valuable to the Army for several reasons. First of all, these results demonstrate that meaningful improvements can be obtained by careful development of new ASVAB composites, validated against more reliable criteria. The potential for increasing these gains through the addition of new predictors other than ASVAB is even more substantial. Second, a system has been developed that can be used to implement this important research result. The performance gains from this implementation are likely to be substantial regardless of how one evaluates it.

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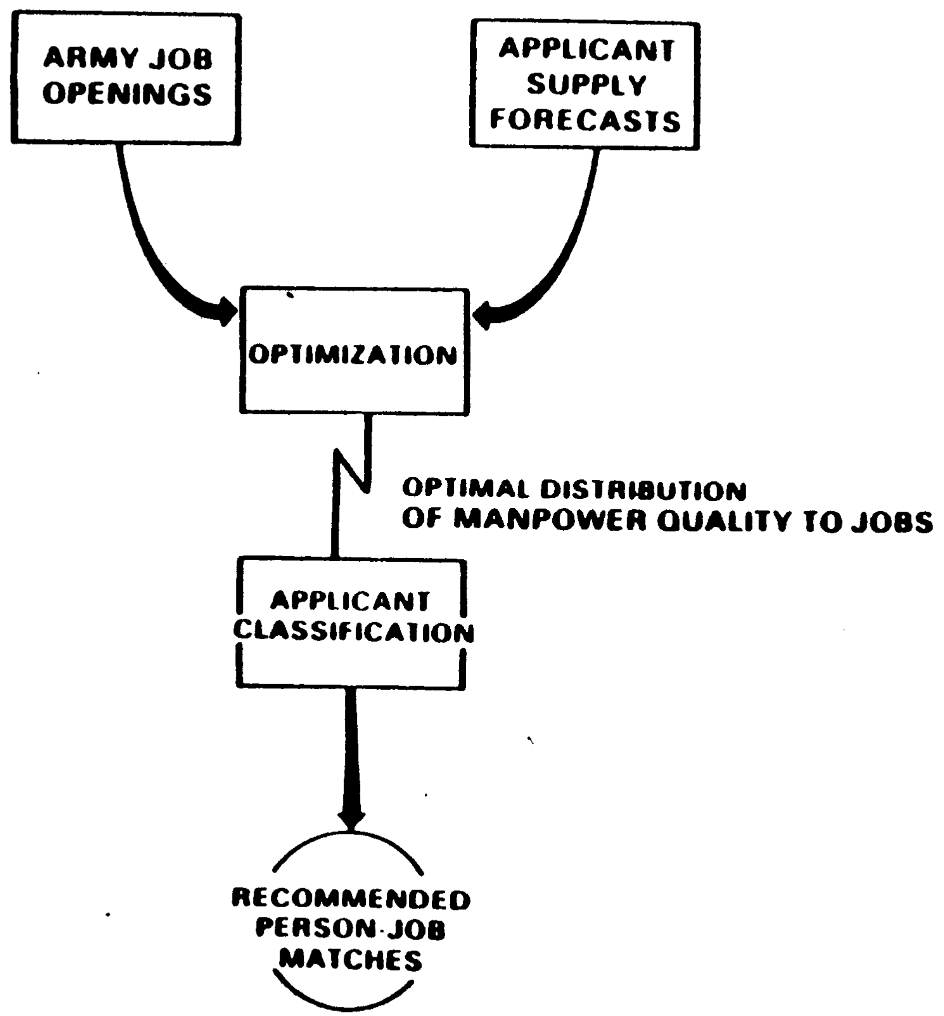
EPAS
APPLICANT CLASSIFICATION



EPAS
Project B

Table 1. Requirements by Aptitude Area

Aptitude Area	Number Assigned	Aptitude Area	Number Assigned
CO	1137	NM	854
FA	237	NG	1535
EL	588	NC	584
OF	637	NE	680
SC	110	NT	448
MM	639	NA	899
GM	321		
CL	510		
ST	821		
Total	5000		5000

Table 2. Aptitude Area Scores for 1984 Army Accessions

Aptitude Area	Mean	Standard Deviation
Clerical/Administrative (CL)	105.12	12.67
Combat (CO)	108.24	12.95
Electronic Repair (EL)	105.77	13.28
Field Artillery (FA)	106.05	12.76
General Maintenance (GM)	106.55	14.20
Mechanical Maintenance (MM)	108.18	12.84
Operators/Food (OF)	107.74	11.77
Surveillance/Communications (SC)	107.93	13.61
Skilled Technical (ST)	105.21	13.78
Mean	106.71	13.10

Table 3. Predictor Score Gains for Alternative Assignment Policies

POLICY	PREDICTOR 6 Composite	SCORE 9 Composite
Random Assignment	106.97	106.71
Current System	108.37	108.47
Optimal Assignment	113.73	113.93
Maximum Placement	114.29	114.41
Operational Assignment	112.00	
Brogden's Formula	114.38	114.80

Table 4. Performance Gains for Selected Assignment Policies

POLICY	PERFORMANCE GAINS (standard units)	
	6 Composites	9 Composites
Random Placement	.219	.204
Present System	.262*	.257
Optimal Assignment	.430	.423
Maximum Placement	.448	.452
Operational Assignment (EPAS)	.376	
Brogden Formula	.451	.449

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11/5/90

Manpower and Personnel Policy Research Group

Working Paper MPPRG 90-10

The Enlisted Personnel Inventory Cost & Compensation (EPICC) Model Conceptual Design and Proposed Application Parts I & II

D. Alton Smith, D. Eichers, P. Hogan and
D. Rose, SRA

5 November 1990

Reviewed by:

Edward J. Schmitz

Edward J. Schmitz
Team Leader, Manpower & Perrsonnel
Planning Team

Approved by:

Curtis L. Gilroy

Curtis L. Gilroy
Chief, Manpower and Personnel
Policy Research Group

Cleared by:

ZITA M. SIMUTIS, Director
MANPOWER AND PERSONNEL RESEARCH LABORATORY

U.S. ARMY RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES
5001 Eisenhower Avenue, Alexandria, VA 22333-5600

DRAFT TECHNICAL REPORT, VOLUME I

CONCEPTUAL DESIGN AND PROPOSED APPLICATION FOR THE ENLISTED PERSONNEL INVENTORY, COST AND COMPENSATION (EPICC) MODEL

Prepared for:

Manpower and Personnel
Policy Research Group
U.S. Army Research Institute

Contract Item Number 0002AG

Prepared by:

Systems Research and Applications Corporation
2000 North Fifteenth Street
Arlington, Virginia 22201

May 1990

DRAFT TECHNICAL REPORT, VOLUME I

EPICC MODEL Conceptual Design and Application

Contract Number	MDA903-89-C-0264
Contract Expiration Date	September 25, 1991
Total Dollar Value	$396,876.00
Short Title of the Contract	EPICC Model
Authors	D. Alton Smith, Ph. D. Danny Eichers Paul F. Hogan Donald E. Rose, Jr.
Name of Contractor	Systems Research and Applications (SRA) Corporation
Contractor's Project Manager	Donald E. Rose, Jr.
Phone Number	(703) 558-4700
Contracting Officer's Representative	Edward J. Schmitz, Ph. D.
Date of Submission	May 31, 1990

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FIGURES

1. INTRODUCTION

The Enlisted Personnel Inventory, Compensation, and Cost (EPICC) Model is a PC-based analysis tool designed to aid Army personnel planners in assessing the inventory and cost implications of changes in compensation and other personnel policies. The prototype version of EPICC is being developed by SRA Corporation under a research and development effort sponsored by the U.S. Army Research Institute for the Behavior Sciences (ARI). This report describes the detailed design for the prototype model. It culminates the design phase of the effort.[1] A preliminary working version of EPICC will be available by the Fall of 1990.

In this introduction we first describe the requirement for a personnel policy analysis tool such as EPICC in Section 1.1. Section 1.2 provides an overview of the design of the model, describing the capabilities of the model in evaluating particular policy issues. Section 1.3 lists the EPICC contract milestones. Section 1.4 outlines the organization of the remainder of the report.

1.1 Requirement for EPICC

Every day Army personnel planners must make decisions about the many policies required to man the enlisted force. To help assess the cost and inventory implications of alternative policies that may be under consideration, they use three general types of personnel policy analysis tools:

- **Inventory projection models.** As the name suggests, a personnel inventory is the stock of soldiers at a particular point in time, arrayed by key characteristics, such as grade

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[1]This report combines the milestone and design reports for Phases I and II of the project, as described in the Statement of Work.

or years of service. Inventory projection models predict how that stock will change over time as individuals enter and leave the force under different personnel policy scenarios. An inventory model can be used to predict losses, determine accession requirements, and identify changes in the composition of the enlisted force.

- **Cost estimation models.** Any change in personnel policies has cost as well as inventory implications. Cost estimation models determine the budget cost of a particular inventory by applying appropriate cost factors to the stocks and flows associated with the inventory.

- **Compensation-retention models.** Changes in military compensation affect reenlistment rates, which are the key input in assessing the year-to-year losses from an inventory. Compensation-retention models provide the quantitative link between compensation policy changes and reenlistment rates.

Army personnel managers currently have available a number of different enlisted inventory models; they have a cost estimation model in the budget version of the Army Manpower Cost System (AMCOS); and there is a substantial body of research on the link between military compensation and reenlistment.

As a system for supporting the analysis of personnel issues, however, the stock of existing tools is deficient in several important respects. First, existing inventory, cost estimation, and compensation-retention models are not linked even though the analysis of many issues requires all three tools. For example, in allocating the dollars available for Selective Reenlistment Bonuses (SRBs), the inventory model identifies projected mismatches between personnel and requirements for the next year. Compensation-retention models show the bonus increase needed to close personnel gaps in particular occupations, and the cost estimation model calculates whether a given allocation of bonuses will be within the total SRB budget. A model integrating the three personnel analysis tools would facilitate the complete evaluation of policy alternatives by eliminating the often difficult task of working with three different, and sometimes inconsistent, models.

Second, many of the existing models are not easily accessible to analysts. The Army's primary inventory model, ELIM-COMPLIP, is not designed to provide

rapid turnaround on inventory projections, an essential requirement if a variety of policy options are to be evaluated within the short time frames usually allowed for policy analysis. In addition, existing compensation-retention models are found only in the research papers describing their development. The econometric framework in which these models are imbedded makes it difficult for the typical analyst to apply the results to particular problems. Having an easily accessible personnel analysis system would reduce the time analysts currently have to invest in building their own analysis tools.

Third, many of the existing personnel analysis tools have key methodological limitations that restrict their usefulness. Inventory models, for example, should be disaggregated both by skill and soldier characteristics. Skill disaggregation is required to analyze occupation-specific compensation issues such as the allocation of SRBs; and disaggregation by key soldier characteristics, such as quality, is needed to understand how personnel policies affect the composition of the force. In addition, existing compensation-retention models, although quite sophisticated from a methodological viewpoint, are restricted in their coverage of the enlisted force, having been estimated for only a handful of occupations.

A number of recent developments have made it feasible to build a personnel policy analysis system that addresses the deficiencies in the current collection of Army tools. First, the recently completed Army Compensation Models Project, which was sponsored by ARI, developed and tested a new generation of compensation-retention models using the reenlistment experiences of soldiers who enlisted from FY 1973 through FY 1984. These models update previous Army research based on pre-AVF enlistments and provide a solid methodological base for constructing software that will estimate the changes in reenlistment rates resulting from changes in a wide variety of compensation policies.

Second, the Army Manpower Cost System, a microcomputer-based cost estimation tool developed by ARI for use by the Army Controller and the Cost and Economic Analysis Center (CEAC), provides the underlying framework needed to

generate comprehensive and accurate estimates of personnel costs. AMCOS offers the analyst a great deal of flexibility in defining cost factors for accessions, training, and force compensation. Thus, cost estimation can be tailored to a particular analysis rather than being a simple extrapolation of historical costs.

Third, recent developments in microcomputer technology make it feasible to build an integrated personnel policy analysis system for the personal computer that also meets the analytical requirements of the analyst. Modest methodological compromises are necessary to use a standard AT microcomputer which is commonly available in analysis shops; even these compromises are not necessary with a more advanced computer platform. Thus, the analyst can have a powerful desktop tool to evaluate more policy options in a shorter period of time.

1.2 Overview of the EPICC Model

Figure 1.1 shows the key components of the prototype EPICC model. In addition to the inventory, compensation-reenlistment, and cost estimation modules which contain the policy tools just discussed, the model includes a user interface which accepts the analyst's scenario assumptions and provides results in a variety of formats. We outline the features of each of the modules in turn, starting with the core of EPICC, the inventory projection module.

1.2.1 Inventory Projection Module

Using a projection scenario defined by the analyst, this module "ages" the baseline enlisted force, determines accessions and promotions, and calculates summary measures describing the projected force. The design for the inventory projection module includes the following features:

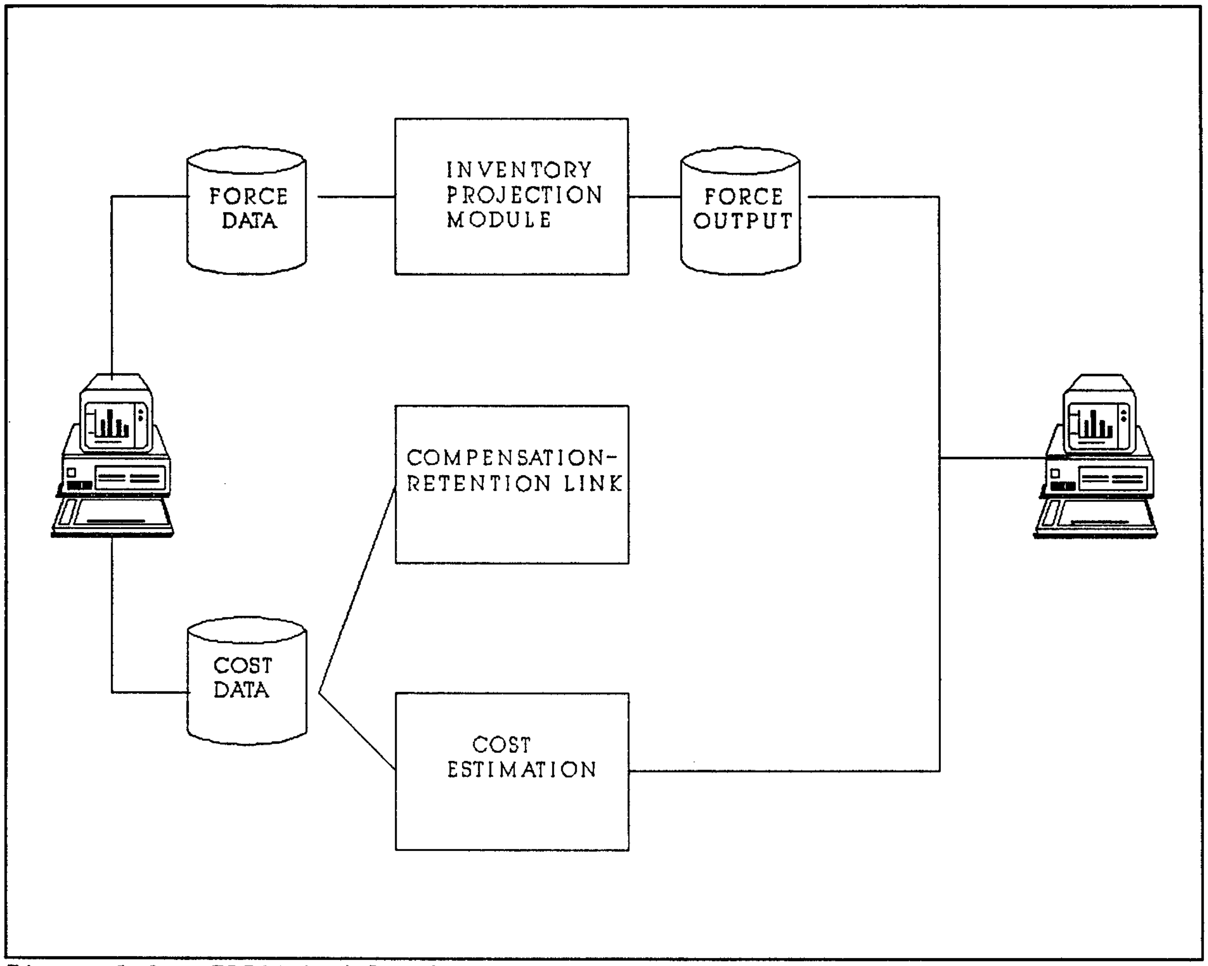

Figure 1.1 - EPICC Model Schematic

- Inventories are dimensioned by both YOS and grade, providing views of the experience distribution of the force by both rank and time in service.

- EPICC will include separate inventories by Career Management Field (CMF). Within skills there are subinventories defined by gender, race (white and minority), and quality. For all-Army projections, quality is divided into six groups (AFQT category I-IIIA, IIIB, and IV for high school diploma graduates and others); for CMF projections there are two groups (AFQT I-IIIA diploma graduates and all others). As noted above, disaggregating inventories allows skill-specific and force composition issues to be addressed by the model.

- The inventory module will produce transitional projections over a nine-year horizon (current year, two budget years, and the six-year planning cycle).

- Inventories can be projected according to an accession or endstrength constraint that is set by subinventory. For example, the model will reflect the differences in how accessions are determined for high quality and other soldiers.
- A time-to-ETS (Expiration of Term of Service) distribution which ages according to enlistment and reenlistment term assumptions will be used to calculate the total continuation rates in the model. As compared with using a static ETS distribution, this approach will capture the inventory effects of policy changes affecting term lengths.

- The rate used to convert accessions into first-year endstrength will be calculated from attrition rates during the first year of service and assumptions about the quarterly timing of accessions. This should improve estimates of the number of accessions required to achieve endstrength targets.

- Soldiers will be promoted to fill vacancies, which are determined as the difference between projected strengths and requirements in a grade. This provides a link between the manpower and personnel worlds as changes in requirements will affect promotion rates. In addition to changing requirements, the analyst can modify the years of service included in the primary and secondary promotion zones and the ratio of secondary to primary promotions.

- In addition to calculating nonprior service accessions, the inventory module accepts user-supplied assumptions about prior service accessions and, in the case of CMF projections, reclassifications into and out of an occupation.

- The inventory implications of a number of additional personnel policies can be modeled in EPICC, including

  - Early decision policies in which soldiers are allowed to make reenlistment decisions before the ETS point, and

  - Changes to retention control points.

- The analyst will be able to directly modify the baseline reenlistment, extension, and non ETS continuation rates. This allows for the evaluation of policies not already programmed into the model.

These design features are derived from our two primary goals for the inventory module -- projection accuracy and analysis flexibility. Our survey of existing inventory models and discussions with the analysts using them suggested features that are important in generating accurate projections, such

as the procedure used to convert accession flows to a first year inventory stock.[2] Analysis flexibility is enhanced by allowing the user to change as many of the assumptions that define a projection scenario as possible. We believe that the EPICC inventory module, as designed, can be used to address a wider variety of personnel issues than the inventory projection models currently available for the Army enlisted force.

1.2.2 Compensation-Reenlistment Module

The compensation-reenlistment module uses the analyst's assumptions about military compensation and macroeconomic conditions over the projection period to predict how baseline reenlistment rates will change in the future. These predicted rates are then used in the inventory projection module to age the enlisted force. The elements of military compensation that can be specified by the EPICC user include:

- Annual increases in basic military pay, both force-wide and targeted to YOS/grade groups;
- Annual changes in allowances by pay grade, including BAQ, BAS, and VHA;
- Annual SRB levels and the payment pattern by MOS; and
- Several options for computing retirement benefits.

In addition the analyst can specify annual changes for the two macroeconomic factors that affect enlisted retention, the level of civilian earnings and unemployment.

Reenlistment rates will be adjusted for compensation assumptions using reenlistment models developed in the Army Compensation Models Project. As part of the development of EPICC, these models will be extended to all CMFs. The prototype for the compensation-reenlistment module is the Army Reenlistment

[2] Appendix A describes the design process for EPICC, including offices briefed and models evaluated.

Model (ARM), which predicts reenlistment rates for seven CMFs using assumptions similar to those defined above.

1.2.3 Cost Estimation Module

The cost estimation module in EPICC will be based on AMCOS. Using the AMCOS data base and policy modules, the analyst specifies assumptions that determine how cost factors for the major cost elements are calculated. For example, assumptions about pay and allowance changes, in addition to affecting reenlistment rates and the inventories, will automatically adjust the cost factors associated with annual compensation. Thus, as in AMCOS, the analyst can tailor the cost factors to suit a particular analysis rather than use historical data that is inappropriate.

The cost factors will be applied against the appropriate flows and stocks derived from the inventory projection module. For example, using analyst-supplied assumptions about the quarterly distribution of accessions, promotions, and losses, the module will calculate the manyears implied by the starting and ending inventories and multiply these manyears by the compensation cost factors to determine the budget costs associated with military compensation.

1.2.4 Operation of EPICC

As required in the development contract, the prototype of the EPICC model is designed to operate on an AT-style microcomputer with a standard 640K of random access memory and a hard disk storage device. The all-Army version of the model will require approximately 5 megabytes of disk storage space and, with a math coprocessor, will be able to generate both inventory and cost projections for a particular scenario in an estimated 15 to 25 minutes. Run times will, of course, be faster on more advanced microcomputers. The complete model with CMF detail will require approximately 7 megabytes of storage.

Our design for EPICC incorporates a number of features to make the model straightforward to use, including:

- **Menu-based operation.** The user will operate the model through a system of menus, including those for defining scenarios, choosing calculation options, and selecting output formats.

- **Default scenario assumptions.** As a result of the flexibility of the model, there are many assumptions in a projection scenario. The model will be delivered with a set of default assumptions based on historical data. In most applications the analyst will only have to change those assumptions relevant to the issue being evaluated.

- **Scenario editing.** To reduce obvious input errors, the user interface will check assumptions on entry and, if necessary, prompt the analyst for a new entry.

- **Automatic file management.** Storage and retrieval of scenario definition, baseline data, and results files will be invisible to the user.

- **On-line help.** Help files accessible during program operation will provide assistance to the user of EPICC. This will complement the written documentation that will be provided with the model.

In consultation with potential users, we have decided that, rather than develop an elaborate output system of reports and graphics generators for the model, results from EPICC will be provided to the analyst in a spreadsheet-compatible form. This gives the analyst the flexibility to perform additional calculations on the results and use whatever graphics packages are available in his or her office. It also saves contract resources for more important work on the substantive portions of the model.

1.3 Project Milestones

Our approach to building the EPICC model will be an evolutionary one. This is similar to the approaches we used for developing the AMCOS and the ARM. In both these projects we were successful in developing a practical and user

friendly model. Based on these successes we believe we can deliver a practical and user friendly EPICC model ahead of schedule.

As we did with AMCOS and ARM, we have worked closely with the Army Staff policy analysts (potentially the primary users) to tailor this model directly to their needs. We will develop a working model by early fall 1990 and use the analysts real world problems to validate the model. The results of actual personnel policy analysis, then, will be used to refine and improve the model to meet the Army's real needs. In addition to making a real contribution to analysis during development, this method has historically provided the contractor with necessary testing, while providing user training prior to actual delivery of the final model.

EPICC CONTRACT MILESTONES

	Contract Milestones	Delivery Date
a.	Draft Report Part I	May 90
b.	Draft Report Part I (revised)	Jun 90
c.	Draft Report Part II	May 90
d.	Draft Report Part II (revised)	Jun 90
e.	Draft Prototype Model	Sep 90
f.	Briefing of Prototype to COR	Nov 90
g.	Draft Prototype Model (revised)	Dec 90
h.	Draft Final Technical Report	Jan 91
i.	Final Technical Report	Mar 91
j.	Final Prototype Model	Mar 91

1.3 Report Organization

The complete design for EPICC is described in two volumes. In this volume, sections 2, and 3 present the analytical design for two of the three key

components of the model, the inventory projection module and the compensation-reenlistment module. In volume II, we present the analytical design for the cost estimation module. For each module, we list the input variables required by the module, including both baseline data and user assumptions, and the output variables generated by the module. We also describe, at the level of specific equations, the calculations which convert the inputs to outputs. The analytical design provides a detailed plan that can be converted directly into computer code. As any design effort involves tradeoffs between the capabilities of a model and constraints imposed by analytical limitations and development costs, we attempt in these sections to identify those tradeoffs and justify our design choices.

Volume II also discusses the technical aspects of the design for the EPICC prototype, including hardware requirements, the user interface, and installation procedures. In this section we also present the key elements of the management strategy for developing the model, such as development milestones.

2. INVENTORY PROJECTION MODULE

The inventory projection module is the core of the Enlisted Personnel Inventory Cost and Compensation Model. Using a projection scenario defined by the analyst, the module "ages" the baseline enlisted force, determines promotions and accessions, and calculates summary measures describing the projected force. This section describes, in detail, our proposed design for the inventory projection module.

There are a variety of approaches to building a personnel inventory model. Section 2.1 outlines the key methodological and operational considerations that motivate our design. The dimensions of the inventory model -- how each inventory is defined and how the overall enlisted inventory is divided into subinventories -- have a significant effect on the size, accuracy, and the policy relevance of the model. Therefore, we begin our description of the design by presenting the dimensions of the EPICC inventory module in Section 2.2. The list of assumptions that comprise a projection scenario influence how useful the inventory model is for policy analysis because it is these assumptions that can be most easily modified by users. Section 2.3 details the elements in the projection scenario for EPICC. Inventory models generate <u>predictions</u> of future personnel inventories; and, as in any forecasting exercise, the quality of the prediction methodology plays an important role in the accuracy of the results. Sections 2.4 and 2.5 describe the EPICC projection methodology, including an overview of the calculations in a typical year-by-year projection and a discussion of the calculation of baseline transition rates. Section 2.6 outlines some possible extensions to the design proposed for the prototype inventory module.

2.1 Design Considerations

Our primary objective in developing the design for the inventory module is the accuracy of the resulting projections. Given the investment in

development costs, an inaccurate model is probably worse than no model at all. In personnel planning, projection errors arise from two sources -- poor assumptions about factors that affect the inventories, such as the future level of military compensation or expected promotion policies, and ill-conceived models for projecting future inventories from those assumptions. The primary goal in our design of EPICC is to reduce the size of the projection errors caused by modeling deficiencies.

Understanding the structure of an inventory model is a prerequisite to identifying the features that will enhance the accuracy of its projections. The typical inventory model is an application of a Markov process in which stocks of soldiers are moved through different states based upon some transition rates. For example, a simple inventory model might dimension the states by year of service, 1 through 30, and projection year. If $E_{i,t}$ is the number of soldiers at year of service i in year t, the expected number at YOS i+1 one year later is given by

$$E_{i+1,t+1} = E_{i,t}\, c_{i,t} \tag{2.1}$$

where $c_{i,t}$ is the predicted continuation rate from year t to t+1, or the proportion of soldiers in YOS i who are still in the Army one year later.

This simple model can be used in two different ways. If the number of new recruits in year t+1, $E_{1,t+1}$, is known, the total number of soldiers in the inventory -- the endstrength -- in year t+1 can be predicted by summing the E's across year of service, or

$$S_{t+1} = E_{1,t+1} + \sum_{i=1}^{30} E_{i,t}\, c_{i,t} \tag{2.2}$$

where S_{t+1} is the endstrength. Alternatively, an endstrength target can be specified and the number of new recruits required to meet that endstrength predicted as

$$(2.3) \qquad E_{1,t+1} = S_{t+1} - \sum_{i=2}^{30} E_{i,t}\, c_{i,t}$$

where the continuing force, soldiers in YOS 2 and greater, is given by the summation term.

These equations show that the accession, inventory, and endstrength predictions of an inventory model all depend crucially on the accuracy of the predicted continuation rates, the c's. Our design for EPICC includes the following features to improve the predictions of continuation rates: a time-to-ETS distribution that is projected along with the inventories; adjustments to the baseline continuation rates for changes in military compensation, macroeconomic factors, and reenlistment management policies; inventories disaggregated by soldier characteristics, such as accession quality; special modeling of first-year attrition; and a systematic methodology for calculating baseline continuation rates. We discuss each feature in turn.

Projected Time-to-ETS Distribution. Because of the difference between continuation rates for soldiers at an Expiration of Term of Service (ETS) point and for those not at ETS, the largest single factor affecting the average continuation rate for enlisted personnel at a given year of service is the proportion of those soldiers facing a reenlistment decision. The EPICC inventory module will employ user-supplied assumptions about term lengths to project how the baseline ETS distribution will change as recruits enter the inventory and soldiers make reenlistment/extension decisions. Existing Army inventory models use a static ETS distribution which will not capture the effects of changing average term lengths on continuation rates.

Adjusted Baseline Continuation Rates. Continuation rates are affected by changes in military compensation; in macroeconomic factors, such as unemployment; and in reenlistment management policies, such as the rules determining reenlistment eligibility. The EPICC user, by altering the projection scenario, will be able to adjust the continuation rates for anticipated changes in these

factors. None of the formal inventory models used by the Army offer this capability, although spreadsheet models constructed by personnel analysts often incorporate a simple compensation-retention link to aid in assessing the effects of pay and benefits changes.

Disaggregated Inventories. Retention research has demonstrated that both ETS and nonETS continuation rates vary significantly with soldier characteristics. To the extent that the composition of the enlisted force changes over the projection period, using continuation rates averaged across the initial force composition will generate inaccurate predictions. However, if the model is disaggregated so that the shift in composition occurs across subinventories, the projection for the total force will reflect the changing average continuation rates. This is the approach embodied in the design of EPICC.

First-Year Attrition Modeling. Given the pyramid structure of the Army's enlisted force, the inventory in the first year of service is typically the largest. The estimate of the first-year inventory depends critically on the attrition rate between the accession point and the end of a fiscal year. This attrition rate depends, in turn, on the timing of accessions during a fiscal year and the distribution of accessions across subinventories. Both factors are considered in calculating the first-year attrition rate in EPICC.

Baseline Rate Methodology. To the extent that inventories are both disaggregated by soldier characteristics and also detailed in their dimensions, baseline continuation rates must be calculated using small numbers of soldiers. This increases the variance of the estimated rates. We have developed a systematic procedure for dealing with this potential problem.

The EPICC design process also considered the usefulness of the resulting model as a policy analysis tool. The usefulness of an inventory model in evaluating personnel policies depends on a variety of factors, including

- **Projection scenario assumptions.** The breadth and detail of the assumptions comprising a projection scenario determine, in part,

the range of policy options that can be easily evaluated with an inventory model.

- **Projection results.** In addition to the basic inventories, other results, such as reenlistments and promotion rates, are required for assessing policy alternatives.

- **Convenience in operation.** One of the problems with most of the existing Army personnel planning models is the time it takes to specify a projection scenario and obtain results. In a fast-paced analysis environment, this necessarily limits the quality of the analyses that can be done.

In our design of the EPICC model, we have incorporated most of the projection assumptions and results suggested to us during our design briefings while keeping the model microcomputer-based for ease of use. The specific features of the EPICC inventory module are described in the next four sections. We start with a description of the basic dimensions of the enlisted inventories.

2.2 Inventory Dimensions

Each inventory in EPICC will be dimensioned by grade (9 columns -- E1/2, E3, E4, E5, E6, E7, E8, E9, and a total) and years of service (31 rows -- YOS 0-1 through YOS 29-30+ and a total). Year of service and grade are the central characteristics of military personnel inventories, related to both the productivity and costs of a particular force. As most of the existing inventory models used by the Army are dimensioned by either grade or YOS alone, EPICC will, by including both dimensions, present a more detailed picture of the enlisted force than is currently available.

The inventories in EPICC will be defined by a combination of military occupation and soldier demographic/quality characteristics. An ideal model would define occupations at the MOS level and disaggregate each MOS by a wide variety of soldier characteristics. This could easily produce over 8000 separate inventories, which would overwhelm the capabilities of existing microcomputers. To keep the accessibility which comes from basing the model on a microcomputer platform, we propose limiting the occupational dimension of the

prototype in two ways. First, occupations will be defined at the Career Management Field (CMF) rather than the MOS level. This level of disaggregation is sufficient for many personnel planning uses.

Second, all-Army projections will be generated from all-Army inventories and continuation rates rather than by aggregating projections for individual CMFs. This allows the EPICC model to operate on an occupation-by-occupation level, where the occupations are CMFs or an all-Army grouping. As part of the definition of a scenario, the analyst will choose an occupation for which inventories and costs should be projected. Although there are some methodological advantages to generating all-Army results by summing the CMF projections, these advantages are clearly outweighed by the operational disadvantages at this stage in the development of EPICC. All-Army projections -- probably the most frequent use of the model -- would simply take too long on a standard-configuration microcomputer if they were accumulated from the projections for 35 CMFs. The current design allows migration to a model in which inventories are defined at the MOS level and all-Army projections generated from the occupation detail, but there are significant computational and analytical challenges in building this model.[1]

Within each occupation (CMF or all-Army), EPICC will project the enlisted force by summing the projections for subinventories, a mutually exclusive and exhaustive set of inventories defined by soldier demographic and quality characteristics. There are two reasons for accumulating the total inventory within an occupation from subinventories rather than directly projecting the total force. First, Army decision makers are often as interested in the composition of the force across these characteristics as in the total numbers. For example, given the focus on the quality content of the enlisted force, it is important to assess the effects of alternative compensation policies on high quality soldiers separately from others. Second, starting with disaggregated projections will, as we have noted, generally provide a more accurate projection of the total force.

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[1]We discuss the advantages of this model and the problems in implementing it in Section 2.6.

The subinventories for EPICC will be defined by the interaction of the following characteristics:

- **Race.** Because of the significant differences in continuation rates between white and minority soldiers, we will distinguish subinventories by these two racial groups.
- **Gender.** Given the limitations on occupations open to women, it is important to include gender in the definition of the subinventories so that these restrictions can be reflected in inventory projections.
- **Quality.** The quality composition of the enlisted force is of continuing policy interest. The EPICC subinventories for all-Army projections will have six quality categories defined by the interaction of AFQT (Category I-IIIA, IIIB, IV) and high school graduation status (diploma graduates, others). For the CMF projections, we will collapse the quality categories into high quality (Category I-IIIA and diploma graduate) and other.[2]

To provide the correct roll-up to the total force, an additional subinventory including all soldiers for whom data on one or more of the above characteristics is missing will also be included. In total, then, there will be 25 subinventories (2 x 2 x 6 + 1) for all-Army projections in EPICC and 9 subinventories (2 x 2 x 2 + 1) for CMF projections.

EPICC will generate transitional or year-by-year inventories for a total of 9 projection years, the current year, two budget years and a six-year planning (POM) cycle. The model will accept separate scenarios for each of the projection years so that the effects of a series of basic pay raises, for example, can be evaluated. In the next section we discuss the elements that define a projection scenario.

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[2]In our conversations with potential users, we found that a finer quality disaggregation was not often needed at the CMF level. Reducing the quality categories from six to two reduces the data storage requirements for EPICC by approximately two-thirds.

2.3 Projection Scenario

The collection of assumptions an analyst can modify in generating inventory projections defines the projection scenario. The major elements of the projection scenario in EPICC include:

- Occupation, a particular CMF or all-Army;
- Military compensation assumptions, such as basic pay raises and Selective Reenlistment Bonus (SRB) multipliers;
- Macroeconomic factors, including unemployment rates and the growth rate in civilian earnings;
- Strength constraints on the inventory, such as endstrengths and accession targets;
- Parameters to define the promotion algorithm;
- Other personnel policies, such as the level of prior service accessions and retention control points; and
- Assumptions about the timing of accessions, promotions, and losses.

The occupation choice has already been described. The military compensation and macroeconomic assumptions are used in the compensation-reenlistment module to calculate factors that adjust reenlistment rates for the effects of changes in relative military-civilian pay. We detail this part of the projection scenario in Section 3, where that module is discussed. We describe the remaining elements of the scenario in order.[3]

2.3.1 Strength Constraints

As described above, an inventory model can be used to determine endstrength, given accessions, or to determine the accessions required to meet

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[3]Additional assumptions define how inventory costs are estimated. As these do not affect the inventory projections, discussion of them is deferred until Section 4.

a particular endstrength. In practice, Army planners often use a combination of these strength constraints in modeling future inventories. For example, high quality subinventories can be considered accession-constrained because of the limits on accessions imposed by recruiting resources. In contrast, accessions into other subinventories are determined by the endstrength remaining after the high quality soldiers are accessed and, therefore, can be called endstrength-constrained.

The analyst will have a great deal of flexibility in specifying strength constraints in EPICC. First, each subinventory is designated as accession-or endstrength-constrained. If the former, the analyst also specifies the expected number of accessions by projection year. For the latter, he has two options:

- Specify an endstrength for that particular subinventory in each projection year, or
- Specify the proportion of unconstrained accessions going into the subinventory. If this option is used for any subinventory, an overall endstrength must also be specified by projection year.

To calculate a projection, the strength constraints must satisfy a set of conditions, such as having one type of constraint specified for each subinventory.[4] The model will verify that an analyst's assumptions meets these requirements as he inputs them.

2.3.2 Promotion Parameters

EPICC will include a vacancy-driven algorithm for determining promotions. Starting with E9, promotions in each grade are determined in a three-step process.

[4]Section 2.4.2 discusses the role of the strength constraints in more detail.

- First, the available E9 slots are determined by multiplying the desired proportion of E9's, which is specified by the analyst, times the endstrength for a particular year.[5]
- Second, vacancies are calculated as the difference between the number of E9 slots and the continuing E9 inventory, which is the number of E9's in the year-end inventory if there were no promotions.
- Third, enough soldiers are promoted from the secondary and primary zones to fill all the vacancies, if that is feasible given the inventories in the promotion zones. The analyst can modify the definitions of the promotion zones and set the ratio of secondary to primary zone promotions. Within a zone, all soldiers are promoted at the same rate.[6]

Promotions to E9 are subtracted from the E8 inventory, and this process is repeated for E8 promotions and the remaining grades.

In addition to providing a reasonable characterization of the promotion process for projecting the grade dimension of inventories, it is through the promotion algorithm that manpower requirements enter EPICC. The effect of changing requirements on promotion opportunities, for example, can be evaluated by suitably modifying the desired grade distribution and observing the resulting change in promotion rates. In addition, the model will identify a faces-spaces mismatch resulting from a given set of personnel policies by calculating manning rates, the inventory in a particular grade divided by the available slots.

There is a conceptual link between the promotion rates determined in the inventory projection module and the military compensation assumptions used in the compensation-reenlistment module. To the extent that major changes in promotion rates occur, the relative military compensation that can be expected by soldiers making reenlistment decisions will change, with a resulting impact on reenlistment rates. Making this link automatically in the model would

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[5]An override will limit the available slots in the senior grades to the Congressionally-mandated maximums. These maximums can be modified by the user.

[6]In the prototype, soldiers will be promoted at the same rate across subinventories, although this can be modified in future versions to reflect historical differences in promotion rates across demographic and quality groups.

significantly increase the time it takes to generate a projection and, therefore, we will not do so in this version of EPICC.[7]

2.3.3 Other Personnel Policies

The inventory projection module will allow the analyst to evaluate the effects of five additional personnel policies -- changing lateral accessions and losses to the inventory, changing reenlistment management policies, modifying retention control points, changing the distribution of initial and reenlistment terms of service, and early decision policies.

Lateral Accessions and Losses. In addition to new recruits, the Army accesses individuals with various years of prior service. In the all-Army model, the analyst will be able to specify the total number of these prior service accessions for each projection year. This accession inventory will be distributed across YOS and subinventory according to proportions that can also be modified by the user. In the CMF models, there are also "lateral accessions" and "losses" as soldiers reclassify into and out of other CMFs. Thus, in these models, the analyst can specify the total losses as well as the total accessions by projection year.

Reenlistment Management Policies. The Army can affect reenlistments and extensions by changing the way the reenlistment process is managed. For example, increased emphasis on retaining high quality soldiers could result in more bars to reenlistment through the Quality Management Program for soldiers in certain subinventories. Because of the wide variety of policy changes that could be implemented, it is difficult to program options for all these management policies in an inventory model. As an alternative, the EPICC inventory projection module will allow the analyst to directly inflate or deflate the rates for reenlistments and extensions, by subinventory, YOS, and projection year, to reflect the anticipated effects of policy changes.

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[7]See Section 2.6 for a description of the solution methodology with the promotion rate linkage.

Therefore, with some side analysis the force structure and cost effects of reenlistment management policies can be evaluated.[8]

Retention Control Points. Soldiers may be denied reenlistment if they have not reached a minimum grade given their years of service. The analyst will be able to modify the control points used in EPICC to assess the change in the number and composition of the losses that would result.

Terms of Service. An important feature of our design for the inventory model is projecting the time-to-ETS distribution along with the inventories. Changes in the distribution of accessions across different initial term lengths and changes in reenlistment terms will affect the time-to-ETS distribution. Therefore, the inventory projection module will allow the analyst to change both of the assumed distributions by projection year. The first term distribution will include term lengths from two to six years. Because two year terms have historically only been offered to high quality soldiers, separate initial term distributions for high quality and other soldiers can be specified. The distribution of reenlistment term lengths will include values from three to six years.

The average extension length also affects the time-to-ETS distribution. As the EPICC is an annual model, there will be only two categories in the extension-length distribution -- one year and two years. Like the term length distributions, these can be specified by projection year.

Early Decision Policies. These policies, which require soldiers to make a reenlistment decision before their ETS date, can be evaluated with EPICC using the time-to-ETS distribution.[9] A user can specify that soldiers at given years

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[8]To increase the flexibility of the model, the EPICC user will also be able to inflate or deflate the nonETS continuation rates, separately by subinventory, YOS, and projection year. Thus, all continuation rates in the model can be easily adjusted by the user.

[9]Early decision policies, as defined here, differ from early reenlistments in that soldiers must opt to reenlist <u>or leave</u> before their ETS. Thus, an early decision policy is a way of reducing endstrength.

of service are eligible for reenlistment even though their ETS date occurs one or two years -- the early decision window is also user-specified -- after the projection year. If an early decision policy is in effect, the model will apply reenlistment rather than nonETS continuation rates to soldiers in the early decision window.

2.3.4 Timing of Accessions, Losses, and Promotions

There are at least two reasons to be concerned about the timing of personnel flows between the year-end inventories that will be projected by EPICC. First, the rate at which accessions are translated into the YOS 0-1 inventory and, therefore, the endstrength depends on when those accessions occurred during the fiscal year. One hundred accessions will result in a higher stock of soldiers in the YOS 0-1 category if they accessed at the end of the year rather than the beginning. In the inventory module, quarterly attrition rates over the first year of service will be weighted by the quarterly distribution of nonprior service accessions to determine the rate at which the accession flow is translated into the YOS 0-1 stock. The EPICC user will be able to set the timing of nonprior service accessions by projection year.

Given the begin-year and end-year inventories, the timing of promotions, losses, and accessions also determines the actual number of manyears available during the intervening year at any grade and YOS combination. As compensation costs are a function of manyears, differences in the timing of personnel flows will affect the cost of a particular inventory. To improve the precision with which costs are predicted in EPICC, the inventory module will estimate the end-of-the-quarter inventories by distributing the annual accession, promotion, and loss flows across quarters.[10] Therefore, in addition to specifying the timing of accessions, an analyst will be able to set the quarterly distribution of promotions and losses by projection year.

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[10]The methodology for doing this is described in Section 4.

Scenario Assumption	Specified By
• Compensation/macroeconomic scenario	(See Section 3.0)
• Occupation (particular CMF or all-Army)	Scenario
• Strength constraints	
- Endstrengths	Projection year, subinventory
- Accession proportions	Projection year, subinventory
- Accession numbers	Projection year, subinventory
• Promotion parameters	
- Required grade distribution	Projection year
- Primary/secondary zones	Grade
- Ratio of secondary to primary zone promotions	Grade
• Lateral accessions/losses	
- Number	Projection year
- YOS distribution	Scenario
- Subinventory distribution	Scenario
• Rate adjustments	YOS, projection year, subinventory
- Reenlistment	
- Extension	
- NonETS continuation	
• Retention Control Points	YOS
• Distribution of term lengths	Projection year
- First	High quality/other
- Reenlistment	
- Extension length	
• Quarterly timing of accessions, promotions, losses	Projection year
• Early decision policies	YOS, time-to-ETS, projection year

Figure 2.1: Inventory Projection Scenario

Figure 2.1 summarizes the projection scenario assumptions that we have discussed in this section. These assumptions, plus the compensation and macroeconomic assumptions presented in Section 3, constitute the inventory projection scenario required for one occupation. Because there are many factors that affect the characteristics of future inventories, a flexible tool for projecting those inventories will, by necessity, need a large amount of user input. In typical policy applications, however, the EPICC user can rely on default values for most assumptions, only changing those parameters related to

the policy issue being studied. The default assumptions supplied with the model will be derived from actual data for the baseline year.

2.4 Projection Methodology

Figure 2.2 provides an overview of the methodology for generating a nine-

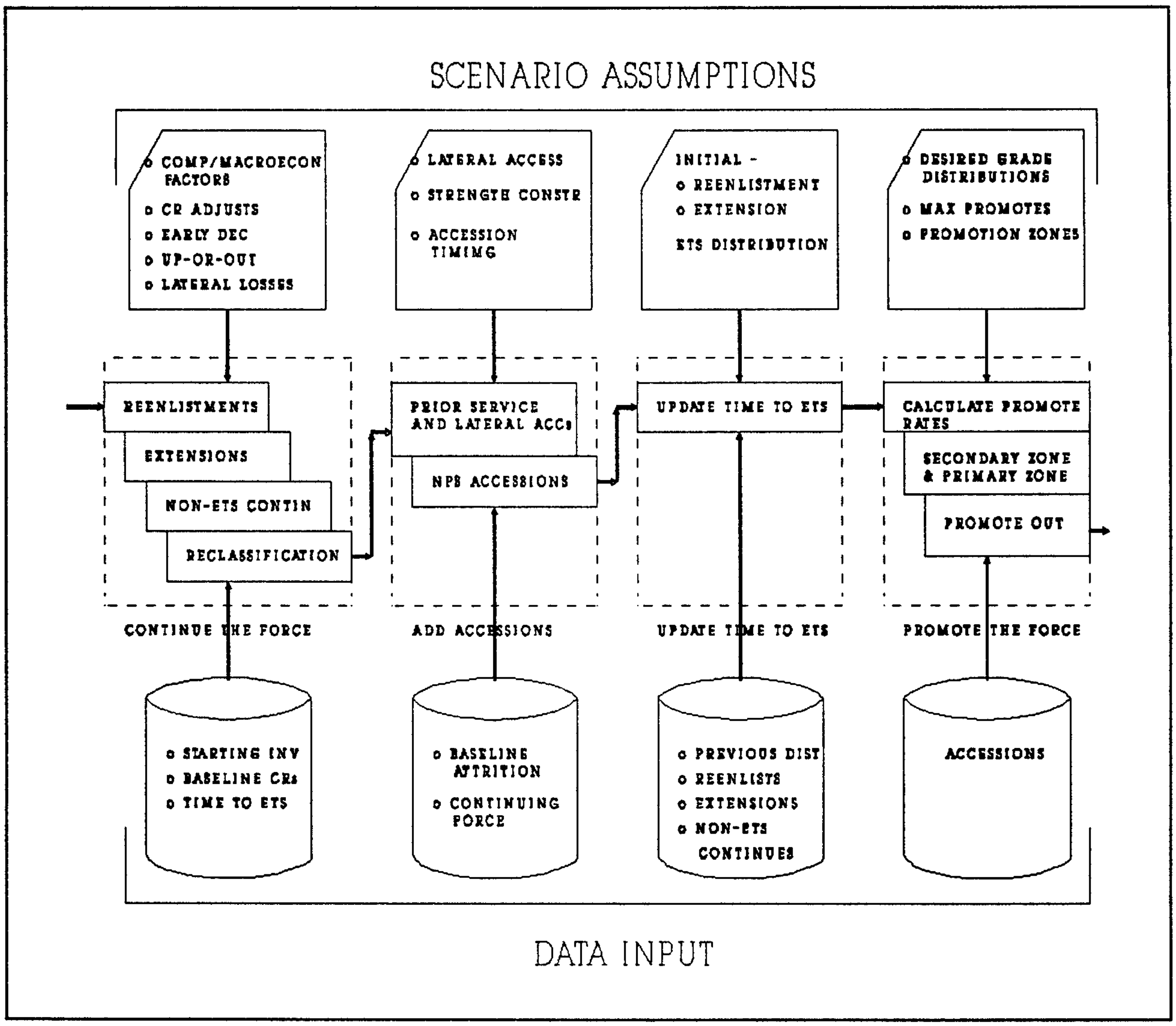

Figure 2.2: Calculating Transitional Projections

year transitional inventory projection for a single CMF or the all-Army model. Four major steps are required to estimate the inventory for each projection year. Starting from the previous year subinventories for the occupation, the continuing force is determined first. Second, nonprior service and other accessions are calculated and added to the inventories. With the flows of personnel into and out of the inventory determined, the time-to-ETS distribution can be updated. Fourth, the inventory is promoted according to the promotion parameters specified by the analyst. These steps are repeated for each projection year. Our discussion of the transitional projection methodology is organized around these four major steps.

2.4.1 Determine the Continuing Force

To determine the continuing force, the inventory module requires five personnel flows: ETS reenlistments; reenlistments before ETS; extensions; nonETS continuations; and, for a CMF projection, reclassifications out of the occupation. With the exception of reclassifications, which are specified directly by the user, these flows are estimated using the previous year's inventories and time-to-ETS distributions, baseline transition rates, and the assumptions specified in the projection scenario. We detail the estimation procedure for each personnel flow in turn.

ETS Reenlistments. In the context of EPICC, ETS reenlistments are defined as those occurring among soldiers who have an ETS date during the projection year. The equation for ETS reenlistments in YOS i, subinventory k, and projection year t, R_{ikt}, is

$$(2.4) \quad R_{ikt} = E_{i,k,t-1} \left[(1-U_{it}) \left(d^0_{ikt} + \beta^1_i d^1_{ikt} + \beta^2_i d^2_{ikt} \right) \right] \left(r_{ik} \, \delta_{ikt} \, \Delta^r_{ikt} \right)$$

where

$E_{i,k,t-1}$ is the previous year's inventory;

U_{it} is the proportion of the inventory subject to retention control points;[11]

d^0, d^1, and d^2 are the proportions of the inventory with an ETS date in current year, the next year, and the one after that;

β_i^1 and β_i^2 are dichotomous variables equal to 1 if an early decision policy is in effect for soldiers in YOS i with future ETS dates;

r_{ik} are baseline reenlistment rates defined by YOS and subinventory;

δ_{ikt} is a reenlistment rate adjustment factor determined by compensation and macroeconomic assumptions; and

Δ^r_{ikt} is a reenlistment rate adjustment factor used by the analyst to model changes in reenlistment management policies.

Equation 2.4 specifies that reenlistments are the product of three major factors -- the number of soldiers in the inventory at the end of the previous year, the proportion of those soldiers facing a reenlistment decision in the projection year, and the predicted reenlistment rate for that year.

The number of soldiers in the previous year's inventory comes from historical baseline data for the first projection year and from preceding iterations of the model for the remaining projection years.

The proportion facing a reenlistment decision is derived from baseline (projection year 1) or projected (remaining years) time-to-ETS distributions. The time-to-ETS distribution describes, for each subinventory, the proportion of soldiers at each YOS who have ETS date in the current projection year, the next year, and so on. The proportion facing an ETS reenlistment decision includes soldiers with an ETS date in the current year plus those with ETS dates in future years, if early decision policies are in effect. This figure is

[11]This is determined by applying the analyst-supplied control points against the previous year's inventory, aged one year of service.

reduced by the fraction of soldiers who will be denied reenlistment because of retention control points.

The adjusted reenlistment rate is the product of baseline reenlistment rates for YOS i in subinventory k and adjustment factors for changes in relative military compensation and reenlistment management policies. In Section 2.5 we discuss the derivation of the baseline rates. The compensation adjustment factor, the output of the compensation-reenlistment module, is described in Section 3. The factor representing changes in reenlistment management policies is supplied directly by the EPICC user.

Reenlistments before ETS. The model will assume that early reenlistments are a user-specified proportion, γ, of ETS reenlistments, or

(2.5) $ER_{ikt} = \gamma R_{ikt}$

Thus, early reenlistments will move up or down proportionally with changes in compensation policies, macroeconomic factors, and reenlistment management policies. We assume that all early reenlistments are made by soldiers who have an ETS date in the year following the projection year. If an early decision policy is in effect for that year, early reenlistments will not be calculated.

Extensions. Extensions in the inventory module are given by

(2.6) $EX_{ikt} = E_{i,k,t-1} [(1-U_{it}) d^{o}_{ikt}] [ex_{ik} \Delta^{ex}_{ikt}]$

where ex_{ik} is the baseline extension rate, defined by YOS and subinventory, and Δ^{ex}_{ikt} is the reenlistment management adjustment factor for extensions. We assume that only soldiers with an ETS in the current year have the option of extending, and that extension rates, unlike reenlistment rates, are not sensitive to changes in relative military compensation.

NonETS Continuations. This flow constitutes the remainder of the continuing force. NonETS continuations are calculated as

$$(2.7) \quad NC_{ikt} = E_{i,k,t-1} \left[(1-\beta_i^1)(d_{ikt}^1 - \{ER_{ikt}/E_{i,k,t-1}\}) + (1-\beta_i^2) d_{ikt}^2 + d_{ikt}^3 + d_{ikt}^4 + d_{ikt}^5 \right] \left[nc_{ik} \, \Delta_{ikt}^{nc} \right]$$

where nc_{ik} is the baseline nonETS continuation rate; Δ_{ikt}^{nc} is the adjustment factor for this rate; and d^3, d^4, and d^5 are the remaining proportions in the time-to-ETS distribution. The nonETS continuation rate is applied against the stock of soldiers with ETS dates beyond the current year, with two adjustments. First, the proportion of soldiers one year away from ETS, d^1, is reduced by the number of early reenlistments. And second, soldiers one and two years away from ETS are not counted in the population subject to nonETS continuations if early decision policies are in effect.

Note that although the inventories in EPICC are dimensioned by YOS and grade, the calculations to determine the personnel flows use continuation rates and time-to-ETS distributions that only have a YOS dimension. This restriction greatly reduces the baseline data requirements for EPICC without, we believe, significantly compromising the accuracy of the projections. Using this approach we are essentially ignoring, <u>for a particular YOS group</u>, any differences in continuation rates or time-to-ETS across grades. These differences are likely to be small.

Given the personnel flows just defined, the continuing force in YOS i, grade j, and subinventory k is calculated as

$$(2.8) \quad E_{ijkt}^{C} = [NC_{ikt} - (\Psi_i \, \Psi_k \, LL_t)] \, (E_{i,j,k,t-1} \, / \, E_{i,k,t-1}) + (R_{ikt} + ER_{ikt} + EX_{ikt}) \, (E_{i,j,k,t-1}^{*} \, / \, E_{i,k,t-1}^{*})$$

where the superscript C denotes the continuing inventory, LL_t is the number of reclassifications out of an occupation in projection year t[12], and Ψ_i and Ψ_k are the YOS and subinventory proportions describing where these losses occur. The continuing force in a particular YOS category equals the sum of ETS

[12]This term is zero in an all-Army projection.

reenlistments, early reenlistments, extensions, and nonETS continuations, minus reclassifications out. NonETS continuations and reclassifications for a YOS category are distributed across the grades using the grade distribution from the previous year. Reenlistments and extensions are distributed according to the previous year's grade distribution with the grades subject to retention control points eliminated.

2.4.2 Add Accessions

The second step in the methodology for generating transitional projections is to add both prior service and nonprior service accessions to the inventory. We discuss prior service accessions first.

Lateral accessions, composed of prior service accessions in the all-Army model plus reclassifications in a CMF model, enter the inventory in years of service cells beyond the first. Lateral accessions by YOS, subinventory, and projection year are first computed using the inputs supplied by the analyst: total accessions by projection year and the distribution of these accessions by YOS and subinventory, ψ_i and ψ_k. These accessions are added to the continuing inventory, using the previous year's inventory to distribute the YOS total by grade, so that

$$(2.9) \quad E^{C+A}_{ijkt} = E^{C}_{ijkt} + LA_{ikt}\,(E^{*}_{i,j,k,t-1}/E^{*}_{i,k,t-1}) \quad \text{for } i \geq 2$$

$$\text{where } LA_{ikt} = LA_t\, \psi_i\, \psi_k$$

The superscript C+A on the inventory variable E indicates the continuing force plus accessions.

Nonprior service accessions, by definition, enter the inventory in the YOS 0-1 cell. Two factors complicate the process. First, the procedure for adding nonprior service accessions to the inventory depends upon whether a subinventory is accession- or endstrength-constrained, an analyst-supplied assumption

described above. Second, there is significant attrition during the first year of service as recruits undergo basic and individual skill training. Unlike prior service accessions, which we add directly into the inventory, nonprior service accessions must be adjusted for the losses that occur between the accession point and the end of a fiscal year. In our design, we pay special attention to the accession-to-YOS 0-1 conversion because of the relatively large number of soldiers involved.

For accession-constrained subinventories, the number of YOS 0-1 soldiers resulting from the accession flow is calculated as

$$(2.10) \qquad E^{C+A}_{1,1,k',t} = A_{k't} \left[\sum_{m=1}^{4} \phi_m \prod_{n=1}^{5-m} (1-a_{nk'}) \right] \quad \text{for all } k'$$

where k′ denotes accession-constrained subinventories, $A_{k't}$ is the number of accessions in projection year t, the ϕ's are the user-defined proportions of accessions in each quarter of the fiscal year, and the a's are 3-month attrition rates for the first year of service in the kth subinventory.[13] The expression in brackets, a weighted average of the attrition rates where the quarterly flow assumptions form the weights, is the rate at which the accession flow, A, is converted into the stock of soldiers in YOS 0-1. Thus, the conversion rate is sensitive both to the timing of accessions and to the distribution of accessions across subinventories.[14]

If a subinventory is endstrength-constrained, the number of YOS 0-1 soldiers is determined in one of two ways, corresponding to the type of endstrength constraint. If an endstrength has been specified for that subinventory, the number of soldiers in the first year of service equals the

[13]The attrition rates in equation 2.10 are defined as the proportion of soldiers starting a three-month service interval who have left by the end of the interval.

[14]Note we assume that all nonprior service accessions enter as an E1 or E2, so that $E^{C+A}_{1,j,k',t} = 0$ for $j \neq 1$. This restriction could be relaxed by allowing the user to specify an accession grade distribution.

endstrength minus the continuing force in the subinventory. If a total endstrength plus an accession distribution is specified, the number of YOS 0-1 soldiers is given by

$$(2.11) \qquad E^{C+A}_{0,1,k,t} = \lambda_k \left[S_t - \sum_{k'} \sum_{i=1}^{29} E^{C+A}_{i,k',t} - \sum_{k} \sum_{i=2}^{29} E^{C+A}_{ikt} \right] \quad \text{for all } k$$

where λ_k is the assumed accession distribution across the endstrength-constrained subinventories and S_t is the total endstrength constraint in year t. The available strength for YOS 0-1 in the endstrength-constrained subinventories -- the term in brackets -- is the total endstrength minus the endstrengths in the accession-constrained subinventories and minus the continuing force plus lateral accessions in the endstrength-constrained subinventories.

Accessions into the endstrength-constrained subinventories are determined from the YOS 0-1 stocks using the accession-to-YOS 0-1 conversion rate, as follows:

$$(2.12) \qquad A_{kt} = E^{C+A}_{0,1,k,t} \Big/ \left[\sum_{m=1}^{4} \lambda_m \prod_{n=1}^{5-m} (1-a_{nk}) \right] \quad \text{for all } k$$

Total accessions in projection year t equals the sum of the A_{kt}'s across all the subinventories.

2.4.3 Update Time-to-ETS Distributions

In the third step of the transitional projection, the ETS distributions associated with each subinventory are updated using the estimates of personnel flows and the assumptions about the term of service lengths chosen at the enlistment, reenlistment, and extension points.

For soldiers in YOS 0-1, the new ETS distribution is determined by the distribution of initial term lengths, which can be different for high quality and other soldiers.

For soldiers in year-of-service categories YOS 1-2 through YOS 29-30+, the new ETS distribution is defined by the following equations:

$$d^0_{ikt} = \{ NC_{ikt} [(1-\beta^1_i)(d^1_{i,k,t-1} - \{ER_{ikt}/E_{i,k,t-1}\})/d^s_{i,k,t-1}] + EX_{ikt}\ \tau_1 \} / E^{C+A}_{ikt}$$

$$d^1_{ikt} = \{ NC_{ikt} [(1-\beta^2_i) d^2_{i,k,t-1}/d^s_{i,k,t-1}] + EX_{ikt}\ \tau_2 \} / E^{C+A}_{ikt}$$

$$d^2_{ikt} = \{ NC_{ikt} [d^3_{i,k,t-1}/d^s_{i,k,t-1}] + \mu_3 [R_{ikt} + ER_{ikt} + LA_{ikt}] \} / E^{C+A}_{ikt}$$

$$d^3_{ikt} = \{ NC_{ikt} [d^4_{i,k,t-1}/d^s_{i,k,t-1}] + \mu_4 [R_{ikt} + ER_{ikt} + LA_{ikt}] \} / E^{C+A}_{ikt}$$

$$d^4_{ikt} = \{ NC_{ikt} [d^5_{i,k,t-1}/d^s_{i,k,t-1}] + \mu_5 [R_{ikt} + ER_{ikt} + LA_{ikt}] \} / E^{C+A}_{ikt}$$

$$d^5_{ikt} = \{ \mu_6 [R_{ikt} + ER_{ikt} + LA_{ikt}] \} / E^{C+A}_{ikt}$$

(2.13)

where $d^s_{i,k,t-1} = (1-\beta^1_i)(d^1_{i,k,t-1} - \{ER_{ikt}/E_{i,k,t-1}\}) + (1-\beta^2_i) d^2_{i,k,t-1} + d^3_{i,k,t-1} + d^4_{i,k,t-1} + d^5_{i,k,t-1}$

τ's = Proportions of short and long extensions

μ's = Proportions of reenlistments by term length

The new proportion with an ETS date in the coming year, d^0, is the sum of short extensions, τ_1 EX, and the nonETS continuations among soldiers who previously had an ETS date one year in the future.[15] The proportion with an ETS date in the year after next, d^1, is similarly defined. For d^2 through d^5, the sum of ETS reenlistments, early reenlistments, and lateral accessions are distributed according to the assumed distribution of reenlistment term lengths and added to nonETS continuations.

[15]Note that soldiers subject to early decisions or making early reenlistments must be removed from last year's value for d^1.

2.4.4 Promote the Force

The final step in projecting an inventory for one year is to estimate promotions, which begins with the calculation of vacancies. Starting with E9's, vacancies in year t are determined as

$$(2.14) \qquad V_{9,t} = \max \{ \min [(S_t\ \pi_{9,t}),\ g_9] - E^{C+A}_{9,t},\ 0 \}$$

where S_t is the total endstrength in year t; $\pi_{9,t}$ is the desired proportion of E9's in the force, a parameter set by the model user for each projection year; g_9 is the maximum number of E9 slots authorized for the Army; and $E^{C+A}_{9,t}$ is the number of E9's in the continuing force. The number of E9 slots available, the expression in brackets, is the minimum of the endstrength times the desired E9 proportion and the ceiling on E9 slots. Vacancies are the maximum of the difference between the available slots and the continuing force, and zero.

Next, we calculate the primary and secondary zone promotion rates required to fill the vacancies. Using the promotion parameters defined by the analyst, we can express E9 promotions as a function of the promotion rate in the primary zone, $\rho_{9,t}$,

$$(2.15) \qquad [\ Z^s_{9,t}\ (\theta\ \rho_{9,t})] + [\ Z^p_{9,t}\ \rho_{9,t})]$$

$$\text{where } Z^s_{9,t} = \sum_i E^{C+A}_{i,8,t} \quad \text{for i in secondary zone}$$

$$Z^p_{9,t} = \sum_i E^{C+A}_{i,8,t} \quad \text{for i in primary zone}$$

$Z^s_{9,t}$ and $Z^p_{9,t}$ are the total numbers of E8's in the secondary and primary zones; they are calculated by summing the continuing plus accessions force of E8's in the user-defined YOS intervals that comprise the zones. The parameter θ is the ratio of secondary to primary zone promotions, which is also determined by the analyst. Putting this information together, the term in the first set of

brackets is the number of secondary zone promotions; the term in the second set of brackets, primary zone promotions.

Setting the promotions equal to E9 vacancies, we can calculate the primary zone promotion rate required to fill the vacancies,

$$(2.16) \qquad \rho_{9,t} = \min [V_{9,t} / (Z^{s}_{9,t}\ \theta + Z^{p}_{9,t}),\ 1]$$

The primary zone promotion rate is constrained to be less than 1. Subtracting the new E9's to obtain the E8 inventory, the promotion rates to E8 can be determined in a similar manner. This process is repeated for E7 through E1/E2.

The final inventory for projection year t is given by

$$(2.17) \qquad E_{ijkt} = E^{C+A}_{ijkt} + P_{i,j-1,k,t} - P_{ijkt}$$

where P_{ijkt} is the promotions out of grade j in YOS i. Promotions out are determined by multiplying the primary or secondary rate, as appropriate, times the continuing force plus accessions. This completes the inventory projection for one year. The process is repeated, using these inventories and time-to-ETS distributions as the starting point, for the remaining projection years.

2.4.5 Projection Results

Figure 2.3 summarizes the potential results that can be generated from the EPICC inventory module for a single projection year. The list includes outputs discussed in the projection methodology, such as reenlistments, as well as force statistics derived from those outputs, including

- **Losses.** These are the difference between the continuing inventory and the previous year's inventory.
- **Fill Rates.** Calculated as the year-end inventory in a particular grade divided by the slots available for that grade.
- **Average Time in Service at Promotion.** Average TIS at promotion

Item	Dimensioned By
• Inventories	Grade, YOS, subinventory
• Time-to-ETS distributions	YOS, subinventory
• Personnel flows	
- Nonprior service accessions	Subinventory
- Other accessions	Subinventory and YOS
- ETS reenlistments	Subinventory and YOS
- Early reenlistments	Subinventory and YOS
- Extensions	Subinventory and YOS
- NonETS continuations	Subinventory and YOS
- Losses	Subinventory and YOS
• Promotions	
- Number	Grade, YOS
- Primary/secondary rates	Grade
- Average TIS at promotion	Grade
• Fill rates	Grade

Figure 2.3: Complete Inventory Projection Results
for a Projection Year

can be calculated by weighting years of service by the proportion of total promotes out in that YOS.

Other statistics can be added as needs are identified.

One "problem" with the results generated by the inventory model is their sheer volume; storing the complete results for a 9-year projection would rapidly fill even a large hard disk on a microcomputer. For this reason, the default procedure for storing projection results will summarize the results in Figure 2.3 in several ways.

- Only the column and row totals from the inventories, rather than the full YOS-by-grade matrix, will be stored. Thus, a vector of soldiers by grade and a vector by YOS will be used to describe each inventory.

- The subinventory results will be stored by the categories defining the subinventories, rather than the subinventories themselves. That is, results for white and minority soldiers, for male and female soldiers, and for the six quality groups will be retained.

- Time-to-ETS distributions will not be included in the summary results.

At the user's option, complete results from a scenario can be stored.

2.5 Baseline Continuation Rates

This section describes our approach for calculating the baseline reenlistment, extension, and nonETS continuation rates required by EPICC. Because these continuation rates are, in principle, disaggregated by YOS, soldier characteristics, and skill, some of the calculated rates will be based on a small number of soldiers. We discuss the ramifications of small cell sizes for the accuracy of the inventory projections and outline a methodology for dealing with the problem.

2.5.1 Basic Approach

Continuation rates will be calculated using the fiscal year-end Enlisted Master Files (EMFs) for the baseline year and the year preceding it.[16] Using the previous year's file, soldiers are first classified according to their ETS date -- within the next (i.e. baseline) year or in the years following the baseline.

For those soldiers with an ETS date in the baseline the following rates will be calculated:

- **Extension Rate.** The proportion of soldiers whose ETS date on the master file for the baseline has increased by less than 24 months.
- **Reenlistment Rate.** The proportion of soldiers whose ETS date has increased by 24 or more months.

These rates will sum to less than one because of losses that occur at the ETS

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[16]Because of the accessibility of the data, we plan to use the Enlisted Master Files maintained by the Defense Manpower Data Center (DMDC) in creating the rates for the prototype model. The same methodology, however, could be applied to the PERSCOM EMFs.

point. Reenlistment and extension rates will be calculated by YOS within each subinventory, for every CMF and the entire Army.[17]

The denominator for the nonETS continuation rate includes all soldiers who, as of the year-end master file preceding the baseline year, have an ETS after the baseline year. The numerator is the number of these soldiers who appear on the master file at the end of the baseline year. As with the reenlistment and extension rates, the nonETS continuation rates will also be calculated separately by YOS for each subinventory.

2.5.2 Small Cell Sizes

As the sample of soldiers used to calculate a particular continuation rate decreases, the standard error of that rate and, therefore, the standard error of the projected inventories based on that rate increase. In the limit, rates for cells with zero members cannot be estimated. One response to small cell sizes is to pool soldiers across inventories, years of service, skills, or fiscal years and calculate rates based on these aggregated cells. This, however, can introduce bias into the estimated rates because the soldiers used to calculate a particular rate no longer have the same characteristics. In general, there is a tradeoff between reducing the variance of an estimated rate and increasing the bias.

We propose the following procedure for dealing with the small cell size problem in EPICC. First, we will identify those continuation rates based on cell sizes of less than 25 soldiers. Below this level, the confidence interval

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[17]An alternative approach is to construct baseline rates by averaging over several years. This reduces the effects that random fluctuations in the continuation rates have on the projections. Unfortunately, it also obscures the effect of recent changes in policy and other factors that will affect continuation rates in the future. Given the dynamic environment that currently exists in military personnel planning, we believe the disadvantages of a multiyear baseline outweigh the advantages.

for predictions based on these continuation rates becomes unacceptably large.[18] Then, we will combine the soldiers in each of these cells with soldiers in the same YOS, race, sex, and quality category in a "related" occupation and recalculate the continuation rates. The pooled rates will replace the rates actually observed in the small-sample cells.

Previous research has shown that demographic and YOS differences in reenlistment rates are substantial, so that pooling across these characteristics would significantly bias the rates. Pooling across fiscal years is also not desirable because it obscures the effects of recent personnel policy changes on continuation rates. The best way to pool, therefore, seems to be across similar occupations, such as within the combat arms skills. We can use standard statistical tests to choose the occupations that are best for pooling.

2.6 Extensions to the Prototype Design

In this section we discuss several possible extensions to the design of the inventory module in the prototype version of EPICC. The inventory module we have described so far is ambitious in that it contains many features not currently available in existing Army inventory models. Because of the resources required to program and thoroughly test the entire EPICC model, we most likely <u>cannot</u> incorporate these extensions in the prototype under the current level of effort. We describe them here to elicit comments on whether they should be added to the prototype, in lieu of some of the proposed features, or be included on a menu of possible future enhancements. We consider five extensions: adding a steady state projection option, improvements to the promotion algorithm,

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[18]An 80% confidence interval for $\hat{E}_{i+1,t+1}$, the predicted inventory in year t+1, is given by

$$E_{i,t}\ \hat{c}_{i,t} \pm (1.28\ E_{i,t}\ \sigma_{\hat{c}})$$

where $E_{i,t}$ is last year's inventory and $\sigma_{\hat{c}}$ is the standard deviation of the estimated continuation rate. If $\hat{c}$ equals .75 and is based on a cell size of 25 individuals, the limits of the confidence interval are approximately 15% above and below the predicted inventory in year t+1.

including an enlistment supply module, modeling inter-occupation migration flows, and disaggregating to the MOS level.

Steady State Projection Option. Steady state projections show the inventory that would eventually be reached if the projection scenario remained constant over time. Steady state projections are only useful for evaluating the long term effects of particular policies because it may take 30 or more years for the steady state to be reached. In fact, choosing policies based on their steady state implications alone is dangerous as the less expensive policy in the steady state may be more costly overall because significantly higher costs are incurred under that policy in the transition to the steady state.

Among potential EPICC users there was considerably less demand for steady state projections than the transitional projections included in the design of the prototype model. Nevertheless, there are certain personnel policy issues, such as retirement changes, that have usually been evaluated with steady state results. Adding a steady state projection option would, therefore, expand the scope of issues that could be addressed using EPICC. Given the proposed design, providing a steady state projection capability would not be a difficult enhancement.

Promotion Algorithm Improvements. The promotion algorithm in the prototype assumes that the promotion rate from a particular zone and grade is the same across the demographic and quality subinventories. In fact, studies of promotion times have consistently found that AFQT scores and years of education are positively related to speed of promotion. Thus, the proposed model will understate the average grade, at a given year of service, for high quality soldiers and overstate it for others.

Different promotion rates can be included in the model with a modest expansion of the promotion algorithm. With the additional information that promotion rates in each subinventory are X% higher or lower than the Army average, equation 2.16 can be modified to calculate the <u>average</u> primary zone

promotion rate to fill the existing vacancies.[19] Some complexity arises in checking that the resulting subinventory promotion rates do not exceed one and adjusting the remaining rates if this is the case.

As noted earlier, the design for the prototype does not automatically assure that the promotion rates determined in the inventory module are the same as the promotion rates used in the compensation-reenlistment module.[20] Making this linkage would require an iterative solution for each projection, with the following steps. First, an inventory projection like that described for the prototype model would be calculated employing the user-defined scenario. Next, the promotion rates generated by the inventory projection module would be transferred to the compensation-reenlistment module, the reenlistment rate adjustment factors recalculated, and a new inventory projection generated. This process would be repeated until the promotion rates at the beginning of a projection were the same as those at the end. These iterations would substantially increase the time to run a scenario, but adding the linkage would be a fairly straightforward modification.

Enlistment Supply Module. High quality accessions are constrained by the resources applied to recruiting. In the proposed design, the analyst can assume that high quality accessions are fixed at some level, but he has to perform a side analysis to determine what number of accessions is consistent with the resources being applied to recruiting. An enlistment supply module would accept as input the user's assumptions about future levels of recruiters, advertising,

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[19] The average primary zone promotion rate required to fill the vacancies is given by,

$$\rho_{9,t} = V_{9,t} \ / \ \sum \alpha_k \ (Z^s_{9,k,t} \ \theta + Z^p_{9,k,t})$$

where α_k is the ratio of the promotion rate in subinventory k to the all-Army average.

[20] As described in Section 3, however, users do have the option of manually changing the promotion rate assumptions used in the compensation-reenlistment module to incorporate this link.

and enlistment incentives, such as enlistment bonuses and education benefits. Using available enlistment supply models, the module would forecast the level of high quality accessions to be used in the inventory projections. Thus, the accession constraint for these subinventories would always be consistent with the recruiting budget.

Inter-Occupation Migration. When generating an inventory projection for a particular CMF in the proposed design, the user can specify the number of expected reclassifications into and out of that CMF. An improvement would be to allow the model to predict inter-occupation migration based upon historical flows and policy choices, such as the level of the SRB in a CMF and restrictions on entry and exit from a CMF. Modeling the migration flows would impose consistency in the number of reclassifications across all CMFs -- all reclassifications out of a particular CMF have to counted as reclassifications into other CMFs -- and simplify the process of choosing policies to meet CMF strength requirements.

Modeling inter-occupation migration is a difficult problem for both computational and analytical reasons. The computational problem arises from the constraint that CMF inventories cannot be projected individually and then summed to an all-Army inventory. Reclassifications into a particular CMF are a function of reclassifications out of other CMFs, requiring that reenlistments and reclassifications out for all CMFs be determined before the final inventory for any one CMF can be projected.[21] The quickest way to calculate an inventory projection under this constraint is to load all inventories into memory at once and solve all the projections together. An inventory-by-inventory approach would at least double the input and output operations required, substantially increasing the time it takes to generate a projection. Using the simultaneous solution approach in a standard microcomputer, we are restricted to approximately 30 inventories per projection.

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[21]Note that allowing an overall endstrength constraint, as we do in the design of the prototype, imposes a similar limitation on the inventory calculations. To determine accessions in the endstrength-constrained subinventories, we have to know the continuing force in all the subinventories.

There are three ways to increase the number of inventories that can be included, allowing for the modeling of inter-occupation migration. Retaining the standard microcomputer platform, we can use an inventory-by-inventory approach and accept the longer times required to generate projections. Second, we probably can use a simultaneous solution approach on a standard microcomputer if we use a single inventory by CMF, forgoing the demographic and quality subinventories. As we have argued above, this is likely to affect the accuracy of the projections and it means the composition-of-the-force questions cannot be addressed. Third, and probably most attractive, we can implement the complete model -- all CMFs with the demographic and quality subinventories -- on a microcomputer with expanded memory and a different operating system. The drawback to this approach is that the special hardware and software needed to run the model could limit its availability to users.

The analytical problems in modeling inter-occupation migration are, however, more difficult than the computation problems. It is straightforward to specify reclassifications into and out of CMFs using results generated by the proposed model and addition information on reclassification rates by destination.[22] The problems arise in determining how personnel policies will affect the reclassification rates. For example, increasing reenlistment bonuses in a particular CMF will, in addition to increasing total reenlistments among soldiers in that CMF, reduce the reclassifications out of the CMF. Currently, there is no empirical evidence on the size of this channeling effect, and attempts to estimate such effects have generally been unsuccessful. Restrictions on migration into and out of particular CMFs also affect

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[22]Let rc_{ij} be the rate at which reenlistments in CMF i migrate to CMF j. In this notation, parameter rc_{ii} is the proportion of reenlistments in CMF i that do not reclassify. Reclassifications out of (RO) and into (RI) CMF i are given by

$$RO_i = R_i\ (1-rc_{ii}) \quad \text{and} \quad RI_i = \sum_j (R_j\ rc_{ji}) \quad \text{for } j \neq i$$

where R_i is reenlistments in CMF i.

reclassification rates so that any historical data on these rates are conditional on the particular policies in effect at the time the data is collected. How the rates would change as the restrictions are modified is difficult to predict.

Given the computational and analytical problems in modeling inter-occupation migration, we chose not to incorporate this feature in the prototype version of EPICC. With a more powerful hardware-software platform, however, the changes required to include explicit tracking of inter-occupation migration would build on the current design rather than require extensive modifications. The question is whether the analytical limitations in modeling the effects of policy changes on migration flows would make the resulting model worth the additional cost.

MOS-Level Model. A frequent comment in discussions with potential users was that a model disaggregated to the MOS level would be more useful than one divided into CMFs. There are at least two challenges in building such a model. First, the computational problem caused by expanding the number of inventories is increased. Even with an improved hardware and software platform for the model, it probably would not be feasible to model subinventories of MOSs. Second, inter-occupation migration at the MOS level is complicated by career paths in which soldiers who achieve a certain rank in a cluster of MOSs are grouped together in a new MOS. The migration resulting from these career paths would have to be built into the inventory projection methodology.

Expanding the prototype model to the MOS level is the most difficult of the extensions discussed here; but given the demand for inventory and cost results by MOS, it may make more sense to work towards this more ambitious goal than adding improvements to a CMF model.

2.7 Summary

In this section, we have presented our proposed design for the inventory module of the Enlisted Personnel Inventory Cost, and Compensation Model. As any model is necessarily a compromise between conflicting goals, we first outlined the objectives underlying our design. Then we described the input data and user assumptions for a projection scenario, the outputs that will be produced by the module, and the calculations involved in moving from the inputs to the outputs. Finally, we listed several features that are not included in the design of the prototype but are candidates for future enhancements to the model.

The next section describes the design of compensation-reenlistment module.

3 COMPENSATION-REENLISTMENT MODULE

The compensation-reenlistment module uses the analyst's assumptions about military compensation and macroeconomic conditions over the projection period to predict future reenlistment rates. These rates are in turn used in the inventory projection module to age the force. By establishing a link between military compensation and reenlistment rates, this module allows the analyst to assess both the inventory and cost implications of different compensation policies, including changes in basic pay, allowances, SRBs, and retirement pay. In addition, the effects of macroeconomic factors on the force, such as unemployment and civilian earnings growth, can be evaluated.

Figure 3.1 provides an overview of the compensation-reenlistment module. User-defined assumptions about compensation policies and macroeconomic factors

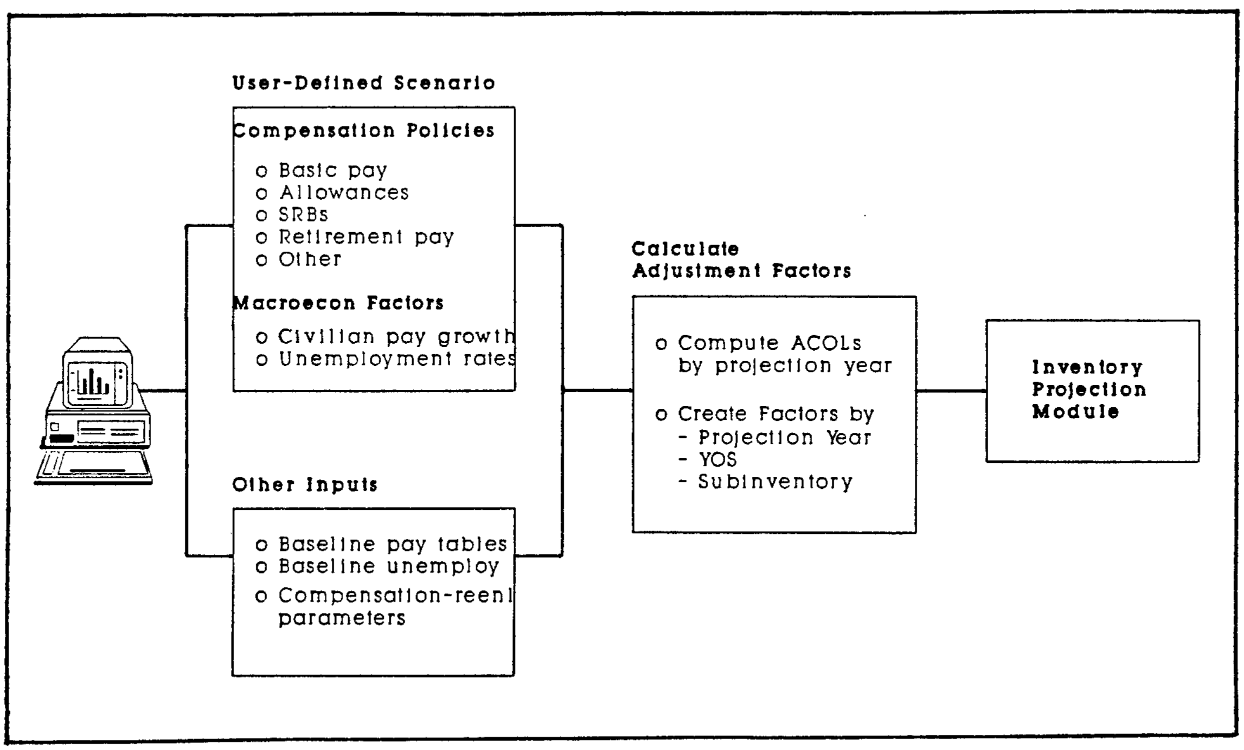

Figure 3.1: Compensation-Reenlistment Module Schematic

are the primary inputs to the module. The outputs are projected reenlistment rates by year and YOS.[1]

As in any modeling effort, the accuracy of the projections under different compensation scenarios is only as good as the quality of the compensation-reenlistment link. Our methodology, derived from the Annualized Cost of Leaving (ACOL) model of reenlistment behavior, has a sound theoretical foundation and a successful track record in similar policy applications. The specific implementation of the methodology is guided by the findings from the Army Compensation Models Project. In this project compensation-reenlistment models were estimated and tested for selected CMFs, and the models were used to develop the Army Reenlistment Model (ARM), a PC-based tool for forecasting reenlistment rates.

Section 3.1 briefly describes the ACOL model to provide the required conceptual background. Section 3.2 outlines how the model will be used to predict reenlistment rates in the EPICC, including the elements that can be modified in defining the compensation/macroeconomic scenario and the prediction methodology. Section 3.3 describes our strategy for estimating the key parameters of the ACOL model linking compensation changes to changes in reenlistment rates, including definition of analysis samples, construction of the ACOL variable, and specification of the reenlistment models.

3.1 Annualized Cost of Leaving Model

The decision to reenlist or enter the civilian sector can be viewed as a special case of the general problem of occupational choice. In choosing an occupation, an individual evaluates the pecuniary and nonpecuniary returns, over his planning horizon, for each occupation in his choice set and selects the one providing the greatest utility. This general concept is too abstract to be used directly in empirical models; functional forms relating the outcomes of

[1]These adjustment factors are the δ's in equation 2.4.

reenlistment decisions to soldier characteristics and behavioral parameters must be specified first. The ACOL model is the specification of this general model that has been used most extensively in studying reenlistment decisions.

We will describe the ACOL model in the context of a soldier making a reenlistment decision at YOS t. The financial returns from staying s more years in the Army for this soldier $RS_{t,s}$1 can be expressed as

$$(3.1) \qquad RS_{t,s} = \sum_{n=t+1}^{t+s} WM_n d^{(n-t)} + \sum_{n=t+s+1}^{t+N} (WC_n + R_{n,t+s}) d^{(n-t-s)}$$

where WM_n is the real value of military compensation in year n, WC_n is civilian earnings in year n, and $R_{n,t+s}$ represents the military retirement benefits, if any, that accrue from t+s years of service. The term d is a discounting factor equal to $(1+r)^{-1}$, where r is the soldier's real discount rate.

Equation 3.1 states that the financial returns to staying in the Army have two components. The first summation is the discounted present value of military compensation paid out during the soldier's career. Compensation is discounted to reflect the time value of money; even without inflation, a dollar paid in the future is worth less than a dollar paid today because currently available dollars can be invested. The second summation is the discounted present value of post-service compensation, including earnings from a civilian job and accrued military retirement benefits.

Similarly, the financial returns from leaving immediately, RL_t, can be expressed as

$$(3.2) \qquad RL_t = \sum_{n=t+1}^{t+N} (WC_n + R_{n,t}) d^{(n-t)}$$

where $R_{n,t}$ is the military retirement benefits after t years of service.[2]

As highlighted in the concept of occupational choice, nonpecuniary factors also play an important role in the reenlistment decision. Because it is difficult to quantify these factors, the ACOL model simply assumes that the difference in the value of these factors in military and civilian occupations, usually called the "tastes" for military and civilian employment, can be expressed as a function of the soldier's characteristics. In particular, the annual value of the nonpecuniary benefits in civilian employment minus those in military employment is given by $\sum \beta_j X_j + \epsilon$, where the X's are characteristics of the individual, the β's are parameters to be estimated, and ϵ is a random error term. For example, because the noncompensation benefits that accrue to individuals with dependents are generally greater in the military than in the civilian sector, the number of dependents is often included among the X's when the ACOL model is estimated.

Combining the financial and nonpecuniary aspects of the reenlistment decision, a soldier will stay if the financial cost of leaving the Army exceeds the value of the nonpencuniary benefits that would be gained by civilian employment. This decision rule can be formalized as

$$(3.3) \quad \text{Stay for s more years if:} \quad ACOL_{t,s} > \sum \beta_j X_j + \epsilon$$

$$\text{where} \quad ACOL_{t,s} = (RS_{t,s} - RL_t) \;/\; \sum_{t+1}^{t+s} d^{(n-t)}$$

In this formulation, the cost of leaving -- returns to staying minus the returns to leaving -- is annualized so that it can be compared with the annual value of the nonpecuniary benefits gained in civilian employment.

ACOL summarizes the financial aspects of the reenlistment decision.

[2]To simplify the exposition, we have assumed that the individual's potential civilian earnings depend only on his total work experience. In fact, research showns that the potential civilian earnings of a veteran depends on the composition of experience between military and civilian jobs as well.

Holding constant the value of nonpecuniary differences -- the right hand side of 3.3 -- the higher a soldier's military compensation relative to his civilian earnings potential and, therefore, the greater his ACOL, the more likely that he will reenlist. Conversely, soldiers who place high values on the nonpecuniary benefits of a civilian occupation relative to a military job (i.e. $\sum \beta_j X_j + \epsilon$ large) are more likely to separate, holding constant relative compensation.

To this point, we have developed the model assuming a particular horizon of future military service, s. In fact, there are multiple horizons--one more term of service, two more terms, etc., all of which imply reenlisting at the current decision point. A rational individual will reenlist if there is at least one horizon where the ACOL exceeds the relative nonpecuniary benefits of a civilian career. Such a horizon exists if the maximum ACOL across all possible horizons is greater than the nonpecuniary benefits, or reenlist if

$$(3.4) \qquad \max_s ACOL_{t,s} > \sum \beta_j X_j + \epsilon$$

This is the ACOL decision rule. If we assume that ϵ has a normal distribution, $N(0,\sigma_\epsilon)$, then the probability that a soldier reenlists at YOS t is given by

$$(3.5) \qquad pr\ (ACOL_t - \sum \beta_j X_j > \epsilon) = \Phi\ (\alpha_{ACOL} ACOL_t + \sum \alpha_{X(j)} X_j)$$

where Φ is the cumulative normal distribution function and $ACOL_t$ is the maximum ACOL across all potential career horizons at year of service t. The unknown parameters of the model -- α_{ACOL} measures the responsiveness of the reenlistment decision to changes in ACOL, the $\alpha_{X(j)}$'s show how other variables such as soldier demographic characteristics or the unemployment rate are related to the reenlistment decision -- can be estimated using a probit model.[3]

The primary advantage of the ACOL model is that it provides a rational way

[3]The α's are related to the variance of taste distribution; in particular, α_{ACOL} equals $1/\sigma_\epsilon$ and $\alpha_{X(j)}$ equals β_j/σ_ϵ.

to decide, for each soldier, the appropriate future career horizon to use in constructing the financial variable for a reenlistment model. This has important implications for assessing the implications of future pays, such as retirement benefits, relative to current compensation. Rather than arbitrarily specifying that retirement pay only begins to affect reenlistment decisions at some year of service, the ACOL model determines the appropriate point by comparing compensation streams across different future careers. Moreover, the methodology is straightforward to implement. With predictions for WM, WC, and R, we can calculate ACOLs for various horizons and choose the maximum before actually estimating any parameters. These two factors have made the ACOL model the most commonly used approach in modeling the compensation-reenlistment link.

3.2 Predicting Reenlistment Rates

The compensation-reenlistment module accepts a user-defined compensation/macroeconomic scenario and uses those assumptions to predict reenlistment rates in the projection years. We describe the elements of the compensation scenario and the prediction methodology in turn.

Compensation/Macroeconomic Scenario. In defining the compensation scenario, the EPICC user will be able to modify the following elements of the military compensation package[4]:

- **Basic military pay.** The analyst can specify the annual percentage increase in basic pay by projection year. A single increase applicable to all grades can be used or the increase can be targeted differentially to particular grades. Future pay tables are generated within the EPICC by applying these percentages to the base year pay table.
- **Allowances.** The annual percentage increases in the Basic Allowance for Quarters (BAQ), the Basic Allowance for Subsistence (BAS), and the Variable Housing Allowance (VHA) can be specified by projection year. These increases can also be targeted differentially to pay grades. Allowance tables in the

[4]Although severance pay is part of the cost estimation module, it is not linked to reenlistment rates.

projection years are calculated from these percentages, the base year tables, and the percentage of soldiers with dependents in the base year.

- **Selective Reenlistment Bonus (SRB).** The SRB inputs depend on the occupation level being considered. For an MOS projection the anticipated multipliers by zone and projection year can be specified by the user. For CMF projections, the multipliers for the MOSs within that CMF are specified and the model calculates an average multiplier for use in determining bonus payments.[5] For the all-Army projection, the annual percentage change in the average SRB multiplier can be specified by projection year. In addition to choosing the level of the multiplier, the analyst can specify the population of the bonus that is paid as a lump sum upon reenlistment. The remaining bonus is paid as annual installments over the term.

- **Retirement Benefits.** The following elements of a defined benefits type of retirement plan can be specified in the EPICC:

    - Benefits accrural rate by YOS
    - Type of cost of living adjustment (COLA)[6]

  The assumed characteristics of the retirement plan can vary by YOS groups allowing grandfathering of existing plans.

- **Promotion Times.** The analyst can specify the percentage increase or decrease in average promotion times to grades E-4 through E-9, by projection year. Future promotion times are calculated by applying these percentages to the average promotion times in the base year.

There are two sets of macroeconomic assumptions that define the civilian pay alternative:

- **Nominal Civilian Pay Growth.** The user determines the expected annual percentage increase in hourly pay for employees in the nonagricultural private sector, by projection year.

- **Unemployment Rate.** This is specified as the national unemployment rate (for workers age 16-64) by projection year.

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[5]The average is calculated by weighting the multipliers by the proportions of the CMF inventory in each MOS during the base year.

[6]If less than a 100% COLA is specified, an assumption about the expected level of inflation over the long run is required.

The military and civilian compensation assumptions are used in two ways in the EPICC. First they enter into the reenlistment rate predictions, as described below. Second, they are used in generating compensation costs for the projection years. Thus, the user need only specify his assumptions once to calculate both the inventory and cost effects of that scenario.

Prediction Methodology. Reenlistment rates in the projection years are predicted in a two step process. First, the compensation assumptions are used to calculate the maximum ACOL values for soldiers in YOS 3 through 30 in the base year and each projection year.

As an example, consider the process for soldiers at YOS 3 in the first projection year. Annual values of military compensation from YOS 3 to YOS 30, the WM_n's in the above discussion of the ACOL model, are generated using the assumed pay and allowance tables, promotion points, and SRB characteristics special pays for the first projection year. Annual values of post-service earnings, the WC_n's, are calculated from earnings models that are described in Section 3.3, adjusted for expected growth in civilian pay from the base year to the first projection year. Retirement pay, the $R_{n,t}$'s, is determined by the assumed characteristics of the retirement system and the basic pay projections.

These elements are combined to form the returns to leaving immediately (equation 3.2) and the returns to staying (equation 3.1) for careers that range from separation at YOS 7 through separation at YOS 30 (i.e. 24 potential career horizons). The model will use a 10% discount rate in determining present values. Finally, the maximum ACOL across different future career horizons is selected. These computations are repeated for YOS 4 through YOS 29 in the base year and each of the projection years.

In the second step, the change in ACOLs and unemployment rates from the base year to a projection year are combined with the base year reenlistment rates to predict reenlistment rates for the projection years. Specifically, the reenlistment rate for YOS t in projection year y is given by

$$r_{t,y} = \Phi[\ \Phi^{-1}(r_{t,o}) + \alpha_{ACOL}(ACOL_{t,y}-ACOL_{t,o}) + \alpha_U(U_{t,y}-U_{t,o})] \quad (3.6)$$

where $r_{t,o}$ is the base year reenlistment rate in YOS t, $ACOL_{t,y}$ is the ACOL value in projection year y for soldiers at YOS t, and U_y is the unemployment rate for year y. In words, we convert the base year reenlistment rate into a probit index, adjust that index for changes in unemployment and ACOL between the base and projection years, and calculate the reenlistment rate associated with the new index. This is a variation of the prediction methodology typically used in those inventory models that include a compensation-reenlistment link.

Both the strength and weakness of this approach to predicting future reenlistment rates is that it bases the prediction on current rates. This is a strength if reenlistment rates have recently changed for nonpay reasons that are expected to persist in the future, such new reenlistment standards. Equation 3.6 incorporates these shifts into the projections for future years by using the base year rates as a starting point. This procedure is inappropriate, however, if the base year rates are unexpectedly high or low for reasons thought to be transitory. As noted in Section 2.0, the analyst will have the option to directly change the base year rates used in a projection. He can use this option if he believes that the base year rates are, for nonpay reasons, not representative of what can be expected in the projection years.

3.3 Estimating the Compensation-Reenlistment Parameters

The reenlistment models we will estimate for the EPICC will be modified versions of the ACOL models developed by SRA for three CMFs in the ARI Compensation Models Project.[7] The modifications are designed to simplify the calculation of the ACOL variable, and thereby decrease the execution time in the compensation-reenlistment module, while still producing estimates of the key parameters that are reasonable given the results of the Project research. We discuss our approach in three parts: the development of the analysis samples,

[7]This research is documented in D. Alton Smith et al., Army Reenlistment Models, SRA report, September 1989.

the calculation of ACOL values, and the specification of the reenlistment models.

Analysis Samples. The compensation-reenlistment models for EPICC will be estimated using the Enlisted Panel Research Data Base (EPRDB), a longitudinal file that tracks a sample of All-Volunteer Force enlisted personnel from accession through separation using data from a variety of personnel records. From the EPRDB we will select, by CMF, samples of soldiers who:

- Accessed from FY 1978 through FY 1984. CMF identification is only available starting in 1978. Although later accessions are included in the EPRDB, first term decisions for many of these soldiers cannot be observed.

- Were still in the Army at six months before their initial ETS date. This eliminates soldiers who leave before completing their first term of service and, therefore, do not face a reenlistment decision.

- Were eligible to reenlist. Including soldiers who cannot reenlist in the analysis sample potentially biases the parameters of the reenlistment model.

- Have complete data on the variables required for the analysis.

ACOL Variable. Military compensation estimates for soldiers in the analysis samples will be built up from pay tables and predicted promotion points, as described above. Civilian pay estimates will be generated from earnings models estimated with the Post-Service Earnings History File (PSEHF) developed by DMDC. The PSEHF includes IRS-reported earnings in 1979 through 1983 for soldiers who separated in 1972 through 1980. Although not without problems -- for example, the military occupation of separatees can only be identified as one of six broad categories of occupations -- the parameters of post-service earnings models estimated with the data set in the Compensation Models Project were reasonable.

In contrast to the Compensation Models Project, we will not allow our predictions of military and civilian compensation to vary by individual characteristics, other than years of service and military occupation. In

particular, we will use average promotion times by CMF rather than promotion time models in calculating military pay and specify post-service earnings for each occupation category as a function of military and civilian experience only. This modification is motivated primarily by concerns about the number of ACOL values that must be calculated in the compensation-reenlistment module. Without individual characteristics, one set of ACOLs by YOS and projection year can be used for all subinventories.

What effect will this have on the estimated ACOL parameter? As long as the difference between the ACOL for a particular subgroup and the occupation-average ACOL is constant, both specifications will yield the same pay parameter.[8] In the Compensation Models Project we found this condition was satisfied for the three CMFs studied, as the pay parameters in both models were similar.

Model Specification. Using the analysis samples defined above, we will jointly estimate models of first and second term reenlistment behavior (estimates of the ACOL and unemployment parameters for third and later terms are discussed below). Joint estimation, known in the reenlistment literature as an ACOL-2 model, provides parameter estimates for second term decisions that are free from dynamic selection bias. We will attempt to estimate separate models for each CMF, although small sample sizes in the EPRDB may require that we pool

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[8]If there are two groups, the reenlistment model with group-specific ACOLs is given by

$$r_{ity} = \Phi\ (\alpha_1 G_1 + \alpha_2 G_2 + \alpha_{ACOL} ACOL_{ity})$$

where i indexes the groups and the G_i's are dichotomous variables equal to one if the observation is in that group. With occupation-average ACOLs, the model can be written as

$$r_{ity} = \Phi\ \{\ [\alpha_1+\alpha_{ACOL}(ACOL_{ity}-ACOL_{ty})]G_1 + [\alpha_2+\alpha_{ACOL}(ACOL_{ity}-ACOL_{ty})]G_2$$
$$+\ \alpha_{ACOL} ACOL_{ty}$$

where $ACOL_{ty}$ is the average ACOL across the groups. If the difference between the group ACOL and the occupation average is constant, only the coefficients on the group variables will change, reflecting the group's <u>relative</u> ACOL in addition to any taste differences.

CMFs with similar characteristics.[9]

Based on our previous research, a working specification of the explanatory variables in the reenlistment models for the EPICC would include:

- ACOL
- National unemployment rate
- Black
- Black * ACOL
- Female (non-combat arms CMFs)
- Female * ACOL
- Second term decision
- Second term * ACOL
- Mental category 1-3A
- 1-3A * ACOL
- High school graduate
- Graduate * ACOL
- Two-year initial term
- Dependents
- Prior service

This specification allows us to test for differences in the compensation-reenlistment link across the subinventories that will be included in the EPICC and across years of service. The α_{ACOL} for any subinventory/YOS is calculated by combining the ACOL coefficient with the appropriate interaction coefficients. For example, the ACOL coefficient for high-quality, black males in the Infantry, facing a second term reenlistment decison, would be given by

$$(3.7) \qquad \alpha_{ACOL} = \alpha_{ACOL,Inf} + \alpha_{ACOL*Black,Inf} + \alpha_{ACOL*1\text{-}3A,Inf} + \alpha_{ACOL*HS,Inf} + \alpha_{ACOL*Term2,Inf}$$

Thus the projection methodology used in the model will reflect not only the differences across subinventories and YOS in the level of reenlistment rates but also differences across these groups in the responsiveness to compensation changes.

In addition to the soldier characteristics that define the subinventories

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[9]An all-Army reenlistment model will also be estimated.

-- black, 1-3A, and high school graduation status -- we include variables for two-year initial enlistments, for dependents status, and prior service. Previous research suggest that all these factors have a significant effect on reenlistment rates. We plan to start estimation with the Infantry, Mechanical Maintenance, and Administration CMFs -- the CMFs studied most intensively in the Compensation Models Project -- and will evaluate this specification based on the results for these CMFs.

Because all soldiers in the EPRBD accessed after FY 1974, it is not possible to use this data set to estimate reenlistment models for the third term and beyond. We don't believe that the effort required to estimate reenlistment models for these decisions is the best use of scarce contract resources. First, results from the Compensation Models Project and other studies agree that the responsiveness of reenlistment rates to relative pay declines as YOS increases. Thus, even large changes in relative pay are likely to have only a small effect on reenlistment rates. Second, because of the pyramid structure of the enlisted force, accurate projections of accession requirements depend more on the accuracy of the first and second term reenlistment rate projections than on the projections of rates for senior enlisted personnel. As a consequence, we propose to initially use judgmental estimates for the pay parameters for these decisions. These will be derived from the pattern of first and second term pay parameters estimated for each CMF. To the extent that resources allow, empirical estimates for the later terms can easily be substituted in the model at a later date.

3.4 Summary

The compensation-reenlistment module allows the EPICC to be used in evaluating alternative pay policies and in assessing the effects of macroeconomic factors on the enlisted force. Our design for this module has the following features:

- A wide variety of military pay policies can be easily modeled.

- The methodology for linking compensation to reenlistment is based on the ACOL model, the most widely used approach in assessing the retention effects of alternative compensation policies.

- The research design for estimating the critical compensation-retention parameters is based on findings from the Army Compensation Models Project.

This completes the discussion of part I of the EPICC model. Part II follows in the next volume of the draft report and discusses the design of the cost estimation module and its integration into the model.